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1.0 OVERVIEW

Olympic Pipe Line Company?s portrayal of the environmental risks associated with constructing and operating its proposed Cross Cascade Pipeline is incomplete and inaccurate. By analyzing each environmental issue in a very vague manner, by leaving out significant relevant information, and by relying on questionable methods of analysis, Olympic has made a representation to the Council that its proposal will have little, if any, environmental risk.

To the contrary, the Cross Cascade Pipeline would introduce significant detrimental risks to sensitive resources in our state. Among other impacts, it threatens the already imperiled chum salmon, coho salmon, chinook, and steelhead. There will be a new threat of groundwater contamination caused by a leak of petroleum into aquifers which are the source of our drinking water. The proposal is inconsistent with Washington State?s efforts to protect and restore salmon resources. Geologic hazards along the proposed route will almost definitely cause or contribute to failure of the pipeline and the pipeline will increase the likelihood of certain geohazards.

To determine environmental risks of the proposal, a decision maker must consider not only the frequency and volume of a pipeline spill or leak, but the consequences of the release. For example, a spill into a sole source drinking water aquifer results in a different risk than the same size spill into a large, slow-moving river. The entire picture of environmental risk should address the ?source,? the ?pathway,? and the ?receptors.? In other words, the Council should first look at and understand how much and how often product may be released from the pipeline (pathway); second, what media the product is entering and how the product will travel (pathway); and, third, the Council should know who or what is impacted by the product (receptors). Are people drinking the contaminated water? Is it entering sensitive fish habitat? How much petroleum must be present to make it dangerous to human health or fish? This report addresses these types of questions and analyzes Olympic?s analysis of risk issue by issue.

The report begins with a comprehensive discussion of geohazards, including landslides, debris flows, stream scour and lateral erosion, culverts, earthquakes, and liquefaction. It then addresses human health risks, aquifer impacts, and surface water impacts. Next, the Columbia River Crossing is examined.

The report also presents five detailed spill scenarios which are reasonably likely to occur. First, is an analysis of the Tolt River crossing, where the immediate impacts and long-term impacts to the state=s fisheries are considered for a rapid release of fuel caused by likely geohazards in the area. Second, the report presents an example of a slow leak, smaller than that which could be detected by Olympic?s SCADA system, leaking into the drinking water for the City of North Bend. Third, the report presents a scenario where a slow leak occurs in the Snoqualmie tunnel which results in an explosion. That scenario demonstrates the potential difficulties for a response in the mountainous terrain. Fourth, the report presents a potential for a release into Swauk Creek in the Upper Yakima Valley. Finally, the report presents the impacts caused by both a slow leak and a pipeline rupture which releases fuel into the Columbia River. There is a very real chance of these types of spills happening as they are based upon real events that have occurred on both Olympic?s pipeline and other pipelines in the United States.

In the end, Olympic?s Application does not rise even to the level of a minimum investigation and analysis that the Council needs to truly understand human health and environmental impacts. This report explains the deficiencies in detail and also demonstrates how proper analysis is conducted. The report also demonstrates risks to certain resources along the route -- not providing a comprehensive analysis of all risks -- rather showing examples of what should have occurred.

2.0 GEOHAZARDS

2.1 INTRODUCTION

The revised Application for Site Certification for Construction and Operation of the Cross Cascade Pipeline (Application) (OPL, May 1 1998) includes a review and evaluation of geohazards. Geohazards are geologic conditions along the proposed route that may pose hazards to the integrity of the pipeline, may exacerbate the environmental impacts of pipeline activities, or may be exacerbated by construction or operation of the pipeline. The Application presents information on geology, geomorphology, geohazards, and their mitigations in Sections 1.4 (Mitigation Measures), 1.5 (Sources of Information), 2.9 (Spill Prevention and Control), 2.10 (Surface-Water Runoff and Erosion Control), 2.14 (Construction Methodology), 2.15 (Protection from Natural Hazards), 3.1 (Earth), 3.3 (Water), and 3.4 (Plants and Animals). Additional information is included in Appendix B including a product spill analysis dated May 24 1997 (Appendix B-2).

The comments in this report address the adequacy of the Application=s evaluation of the geology, geomorphology, and geohazards, including landslides, debris flows, stream scour and lateral migration, erosion, culvert failures, earthquakes/seismicity and liquefaction. For each item, this report provides a short summary of the Application presentation followed by a critique of the Application. The critique includes recommendations for an improved evaluation to gain a better understanding of risks.

In this report, geohazards are addressed as follows:

The landslide discussion focuses on the downslope movement of soil and rock under the primary influence of gravity. Landslides, as discussed here, are called mass wasting in the Application. Landslides include rock falls, rock slides, soil creep, and debris flows. These phenomena are typically evaluated together in landslide hazard analysis. They tend to be controlled by similar variables such as slope angle, soil or rock strength, soil thickness, water table depth, etc. As a result, they often can be mitigated by techniques such as subsurface drainage, modifying the hillslope profile, strengthening the failure surface, etc. Although debris flows differ because they behave more as a fluid, they often are initiated by shallow landslides. For this reason, they are discussed with landslides.

Stream scour and lateral erosion are discussed separately because they pose a distinct and substantial hazard to the pipeline. This discussion is limited to stream bed and bank erosion caused by water flowing in the stream channel. It does not include channel scour caused by debris flows, which are discussed under landslides.

The erosion discussion focuses on the detachment and removal of soil and rock by the action of running water and wind. Erosion includes raindrop, sheet, rill, and gully erosion as well as associated sedimentation. Erosion is important because the resulting sediment can have a very significant adverse impact on streams, wetlands, fish, and other aquatic life.

Culvert crossings are discussed separately. Although they are not strictly geohazards, their performance is closely linked to natural processes contributing to geohazards, and their failure can cause other geohazards.

Earthquakes, as used in this document, refers to earthquake activity and the earth vibrations that occur as a result of earthquakes. It is discussed separately because special geological, geophysical, and engineering methods are used to evaluate and reduce seismic risk.

Liquifaction is the sudden loss of strength of saturated sandy or silty soil. It is most often triggered by seismic shaking, although non-seismic liquefaction is possible. Special engineering designs are used to mitigate liquefaction damage.

2.2 GEOLOGIC RISK OF CASCADE MOUNTAIN PIPELINE

The proposed pipeline would cross the Cascade Mountain range and would be exposed to more geohazards than other pipelines in Washington State and most pipelines in other parts of the United States. The geohazards are greater because the Cascade Mountain range is a Ahigher energy@ environment than, for example, the Puget Sound Lowland, Willipa Hills, and Columbia River Valley, where much of the existing OPL petroleum pipeline is located. The Cascade Mountains are characterized by high peaks, steep slopes, rugged terrain, swift streams with large woody debris, abundant rain and snow, lush temperate rainforest, and forest fires. As a result, this environment is subject to much higher rates of erosion, sedimentation, and mass wasting.

Pipeline risk analysis, discussed in a separate Cascade Columbia Alliance report, considers both the frequency and quantity of petroleum associated with leaks and ruptures from the proposed CCPL report based on applying correction factors to a Ageneric@ pipeline. Correction factors have been developed to address the age, diameter, design factors, and operational factors for the pipeline. Correction factors have not yet been developed to address mountainous terrain and associated geohazards.

Without the benefit of quantitative evaluation, it is still important to address in a qualitative manner the variation in spill frequency and spill volume associated with a mountain pipeline. Consideration must also be given to changes expected over the project lifetime. Shown below is Table 3.18-3 from the DEIS, which lists the causes of pipeline spills in recent years for the average Ageneric@ pipeline.

Cause of Spill	Percentage in U.S. 1980 – 1990	1994 – 1996
Third-Party Action, including Natural Causes	31	26
Corrosion (Internal and External)	27	23
Operator Error	7	7
Material Failure	4	5
Weld Failure	2	6
Other/Unknown(1)	29	33

Source: Office of Pipeline Safety 1990, 1997.

(1) Since 1985, a separate recording of pipeline failures due to Amalfunction of equipment@ has been maintained by the USDOT Office of Pipeline Safety. This category appears to contain between 3 and 9 percent of all incidents. Prior to 1985, malfunction of equipment was included in the Aother@ category, and has been included here in the Aother@ category for consistency over the time period used.

On balance, the frequency of failure for a mountain pipeline during the early years of operation would be slightly greater than the generic pipeline (Mastandrea 1999, personal communication with H. Landau). A higher incidence of failure for geohazards and corrosion could be offset by the reduced incidence of construction damage. Over the life of the pipeline, this difference could increase further as development pressures cause an increase in construction damage to mountain pipelines.

In contrast to the frequency of failure, it is very likely that the mountain pipeline would release much greater volumes to the environment than the generic pipeline. All factors point in that direction. The ability to detect a leak, especially by visual inspection, will be far more difficult, and perhaps impossible when the route is covered with snow. Higher pipeline operating pressures and higher static (non-pumping) pressure at low points will result in greater leak volumes for a given size leak. It will also be more difficult and take more time for response crews to respond to a leak or rupture, thus allowing more product to escape. Finally, the mountain terrain will make it far more difficult to contain a spill, thus allowing more petroleum to seep into the ground or drain into a river or creek. As development along the pipeline route takes place, the difference in volume lost between mountain and lowland pipelines will decrease but will not be eliminated.

Perhaps even more important than the frequency and volume spilled are the locations where releases are likely to occur in mountainous terrain. Many of the releases for a lowland pipeline occur in commercial and industrial areas removed from sensitive environmental receptors. In contrast, many of the geohazards likely to impact a mountain pipeline are in or near fish bearing streams, wetlands, or other sensitive areas. Furthermore, the proposed pipeline would encounter far more of these sensitive areas per unit length of pipeline than most pipelines. Thus, the environmental consequences of spills from the proposed pipeline are likely to be considerably greater.

The proper design of the pipeline will be much more difficult because of the presence of numerous geohazards and the Aindefinite@ life of the pipeline. In addition to the design of the pipe and related fixtures, the design life (the period of time a structure is designed to function before the risk of failure is unacceptable) has a very significant influence on the potential impacts associated with geohazards. For a given probability of failure, the design flood, design scour depth, design earthquake, design slope stabilization measures, and design liquefaction potential will all vary with the design life. For example, the scour depth associated with a 50-year, 100-year or 150-year pipeline life will be greater than that for the reported 30-year planning period. If, however, the intent is to design the pipeline for a 30-year life, but operate for more than 30 years, it is imperative that the pipeline be thoroughly re-evaluated, redesigned, and reconstructed prior to the end of its design life. Since this is probably not OPL=s intent, it is important to eliminate the ambiguity of a reported 30-year planning period and an indefinite life.

2.3 GEOLOGY AND GEOMORPHOLOGY

2.3.1 APPLICATION PRESENTATION

The geologic conditions along the proposed route are described primarily in Section 3.1 (Earth). The Application divides the route into segments and discusses the Anature of the foundation materials@ in each segment. The applicant's Geologic, Topographic, and Mass Wasting Hazard (GTMWH) Maps illustrating the locations of the geologic units and hazards for a Astudy area@ **?-mile wide along the route are included in Appendix B. A discussion (pp. 3.1-2 to 10) and information in Table 2.10-1 (p. 2.10-6) provide a general geologic history of the processes that created the landscape, and more detailed information on the bedrock and unconsolidated deposits likely to be encountered during construction. The descriptions of the bedrock include geologic age and rock type. Sometimes structural information is provided, such as bedding or foliation orientation, and fold and fault information. The descriptions of the unconsolidated deposits generally include genesis, texture, and density.**

Section 3.1 also has some brief discussions of soil erosion (pp. 3.1-19, 23, 33) and references the Soil Types and Erosion Hazard (STEH) Maps in Appendix B. The discussion includes information on soil erosion potential and where erosion-susceptible soils generally occur. Also described are some of the processes affecting erosion.

Topography is discussed on pp. 3.1-24 to 30 with reference to the GTMWH Maps in Appendix B. Topography is discussed by dividing the proposed route into segments and discussing general topographic features of each segment such as typical slope angles.

Groundwater conditions are described in Section 3.3.5. The focus of this discussion is mainly on groundwater resources, not shallow groundwater. Shallow

groundwater conditions are important because they can influence surficial processes like mass wasting.

2.3.2

CRITIQUE

The discussions on geology, geologic hazards, topography, erosion, and groundwater do not identify the geomorphic processes currently shaping the landscape that are critical for an understanding of the impacts to, and potentially caused by, the proposed pipeline. Processes of denudation and accretion will continue to act on the landscape during pipeline construction and operation. These processes, and potential problems associated with how they interact with the pipeline, are not clearly articulated. Furthermore, the impact of future land use activities on geomorphic processes is not discussed.

For example, the Application (p. 3.1-6) identifies an alluvial fan along the route north of Ellensburg and notes that the fan deposits Awere deposited from rapidly aggrading braided streams which flowed from the highlands to the north. In many places these streams eroded into Tertiary age gravels of similar depositional style, but which now form higher terraces of consolidated gravel such as Thorpe Gravels.@ The associated GTMWH Maps 45 and 46 do not show any geohazards; STEH Maps 45 and 46 indicate the soils have a high erosion hazard. Page 3.1-33 states the moderate to high erosion potential is Afrom water and wind erodability criteria." The topography discussion (p. 3.1-26) notes the alluvial fan terrain but does not provide much additional information. The groundwater discussion (pp. 3.3-56 and 61) indicates alluvial deposits are present with Atypically shallow water table associated with surface water bodies, and floodplains.@

The Application indicates that the main processes active in the past on the alluvial fan were deposition and, possibly more recently, incision. It is not clear if either, or both, of these processes, are currently active. The information provided does indicate that the surficial soil in this area currently is highly susceptible to erosion by water and wind, but it is not clear where any eroded soil would be deposited and if this would have any effect on the environment or the pipeline.

Without identifying the active geomorphic processes, the potential hazards to the pipeline are difficult to predict. If fan deposition is currently active, then there is a risk the stream would leave the channel, move across the fan, and scour a new channel through the easily erodible soil, possibly exposing the pipeline. If incision is currently active, then there is a risk the channel bed would eventually be lowered to within scour depth of the pipeline. Perhaps these processes were active in the past, but irrigation withdrawals and surface water diversions have increased or decreased their importance. The Application should clearly identify the geomorphic processes that will affect the pipeline in sufficient detail to understand the risk.

Information is also needed on likely changes in future land use activities and natural phenomena over the lifetime of the proposed project. Some events, such as tree

harvest, forest fires and land development, may occur rather infrequently but have a significant effect on geomorphic processes operating on large land areas. Identifying these processes and where they are likely to occur during the design life of the project is important for predicting geologic impacts to and from the pipeline.

<u>The elevations on the GTMHW maps cannot be consistently determined.</u> Contour elevations cannot be identified in areas with moderate or hummocky topography. Consequently, the shape and slope of the ground surface and the elevation of water bodies cannot be determined. As a result, evaluating surficial processes such as runoff, stream scour, landslides, and debris flows is not feasible.

2.4 LANDSLIDES

2.4.1 INTRODUCTION

Landslides pose a serious risk to the proposed pipeline and one that could easily be underestimated. According to Schuster (1996), landslides are responsible for considerably greater socioeconomic losses than generally recognized. Although landslides cause significant damage in many major multiple hazard disasters, landslide damage is often not documented because it is considered a result of the triggering process. Thus, the news media reports focus on earthquakes, floods, volcanic eruptions, and typhoons, even though the cost of damages from landslides associated with these multiple hazard disasters may exceed all other costs.

Schuster (1996) also states that landslide activity is increasing and expected to increase into the 21st century in spite of improvements in recognition, mitigative measures, and warning systems. He attributes this to the following three causes:

Increased urbanization and development in landslide prone areas
Continued deforestation of landslide-prone areas
Increased regional precipitation caused by changing climate patterns.

The evaluation of landslide hazards presented in the Application is not comprehensive enough given that a major environmental disaster could result from a landslide-induced pipeline rupture. A comprehensive landslide evaluation can be accomplished in many ways and should include most of the following steps:

Step 1: Review the available literature and historic aerial photographs and begin a landslide inventory.

Step 2: Conduct field surveys by qualified geologists and geotechnical engineers for missing and additional information and complete the landslide inventory.

Step 3: Based on 1 and 2 above, identify the landslide processes, sensitive landforms. and triggering mechanisms that are associated with landslides.

Step 4: Identify the potential impacts that landslides could have on the pipeline.

Step 5: Identify the potential impacts construction, operation, maintenance, and decommissioning of the pipeline could have on landslides.

Step 6: Review county and local ordinances for potential screening criteria for identifying landslide prone areas.

Step 7: Review published screening methods (such as models).

Step 8: Establish unambiguous screening criteria based on steps 3 through 7. Where county and local criteria are excluded, provide a clear explanation.

Step 9: Fill in data gaps by conducting additional limited scope literature, topographic, geotechnical, and groundwater studies.

Step 10: Establish an unambiguous landslide hazard rating based on current and potential future conditions.

Step 11: Since active and dormant landslide areas represent a very high hazard, establish the cause of past landslide activity and identify potential trigger mechanisms for further movement.

Step 12: For those locations identified as having a high landslide hazard rating, either reroute pipeline to lower hazard location or conduct a comprehensive and quantitative geotechnical investigation of the site and surrounding area.

Step 13: For those locations identified as having a moderate landslide hazard rating, either repeat Step 11 or identify reasons this is not necessary.

Step 14: Develop appropriate engineering designs and mitigation measures.

Step 15: Perform long-term monitoring of slopes with significant risk of movement.

2.4.2 STEP 1, REVIEW LITERATURE AND AERIAL PHOTOGRAPHS AND BEGIN A LANDSLIDE INVENTORY

2.4.2.1 Application Presentation

The Application (p. 2.15-23) states that the landslides along the proposed route were identified by reviewing aerial photographs, geology, and topography. In addition, Asubsequent field and aerial reconnaissance aerial photographic interpretation and field investigation were used to refine the inventory and determine the need for protective measures@ (sic)(pp. 2.15-14 to 15).

2.4.2.2 Critique

Credible information on landslide hazards was not used. A thorough literature review would include contacting landowners and land managers in the basins of interest for anecdotal information and unpublished reports as well as reviewing publications. Information would be sought on topography, geology, soil, the thickness of unconsolidated deposits, rock structure, shallow groundwater, mass wasting processes, mass wasting features, triggering mechanisms, land use, etc. Agencies, such as the highway departments, may have records indicating where slope instability problems are located (e.g., Lowell 1999). Landowners and and managers, such as timber companies, are also likely to have unpublished reports and anecdotal information on mass wasting processes and triggering mechanisms. A thorough literature review may also reveal several sources for aerial photographs and various types of maps.

The text in the Application does not indicate the scope of the literature review and the information provided suggests it was not comprehensive. For example, the Application (p. 2.15-23) states the Ascreening procedure consisted of an office study of air photographs, geology, and topography followed by field reconnaissance to selected sites.@ The text in Section 2.15 does not indicate that reports or publications on landslides and other forms of mass wasting in the basins of interest were reviewed. Mass wasting inventories and evaluations prepared for the watershed analyses would be especially useful for identifying landslide prone areas as well as activities that exacerbate landslide rates (e.g., Mt. Baker-Snoqualmie N.F. 1987; Weyerhaeuser 1993, 1995).

The aerial photographic analysis appears to be inadequate. The scope of the aerial photographic investigation is not described in the text. However, a reference for Triathlon Mapping Corporation (p. 1.5-6) indicates only 1995 aerial photographs with a scale of 1:18,000 were studied. The analysis appears to have been restricted to hazards in the **?-mile wide study area. As a result, landslide hazards farther than approximately 1320-ft from the proposed pipeline location were not evaluated. This is likely to be inadequate for the mountainous regions, especially when debris flows triggered by slides are of concern. The scale of the photographs does not offer sufficient resolution. Site-specific landslide evaluations typically use 1:15,000 photographs or better (Soeters and Van Westen 1996). Aerial photographs with 1:12,000 scale are available from the Department of Natural Resources. Apparently, these and other photographs taken every five to ten years for the entire period of record should be studied.**

2.4.3 STEP 2, CONDUCT FIELD SURVEYS AND COMPLETE LANDSLIDE INVENTORY

2.4.3.1 Application Presentation

The Application (p. 2.15-23) indicates that field reconnaissance was accomplished at selected sites as part of the initial Ascreening process.@ In addition,

Asubsequent field and aerial reconnaissance aerial photographic interpretation and field investigation were used to refine the inventory and determine the need for protective measures@ (sic) (pp. 2.15-14 to 15).

2.4.3.2 Critique

<u>The scope of the field investigations was inadequate.</u> Field surveys are conducted to develop a better understanding of the landslide processes and hazard areas that could affect the pipeline (and vice versa). This requires studying the landslide sites identified in the previous steps. Site-specific information is collected to: provide an indication of whether the aerial photographic features were properly interpreted; indicate which landslide processes occurred (or are occurring); indicate what physical features are associated with the failures; and indicate what triggered the slope failures.

In addition to studying landslide features observed in the aerial photographs, sites should be selected and studied for evidence of landslide processes that may not be evident on the aerial photographs. Landslides may not be evident because: photographs are not available, they lack sufficient resolution, or features were obscured by vegetation or clouds. For example, steep slopes along the proposed route should be examined to determine the depth of soil creep.

Specific geologic or stratigraphic conditions that are typically associated with landslides should also be fully checked. For example, areas of permeable surface soil underlain by impermeable silt and clay is a recognized landslide stratigraphic sequence in Central Puget Sound (Galasten & Laprade 1991).

Out of a total of 41 identified landslide hazards (Table 2.15-4) on the preferred route, 20 were evaluated by aerial photographs, Avisual,@ or a combination of aerial photographs and Avisual@ (Avisual@ is not defined). Soil borings were drilled at only nine locations. The Application does not state the criteria for determining which sites were visited. Apparently, no sites outside the ?-mile study area were studied. In addition, there is no indication that sites not identified in aerial photographs were visited. This is inadequate, especially where tree canopy obscures the terrain. Furthermore, there is no evidence that the locations and depth of active soil creep were evaluated.

Except for the rare case of a completely unfractured rock unit, the majority of rock masses consist of assemblages of intact rock blocks delineated in three dimensions by a system of discontinuities. In most cases, the engineering properties of fractured rock masses, such as strength, permeability, and deformability are more dependent on the discontinuities than on the properties of the intact rock (Norrish and Wyllie 1996). Furthermore, the susceptibility to groundwater contamination is

controlled by the rock structure and discontinuities. The absence of information on rock discontinuities in the GTMWH maps and text suggest that they were not evaluated, and the risk of rock failure is, therefore, incomplete.

The determination of slope angle is not explained. This would not be a problem if the angle for a given slope was constant and the slopes were of constant height. Since that is not the case, it is important to know how the slope changes with distance from the pipeline. This normally requires field measurements. Slope angles obtained from topographic maps are limited by the resolution of the aerial photographs used to make the maps or digital elevation models (DEMs). For example, elevation values over a 30-meter grid of points, such as provided by the USGS DEMs, cannot resolve topographic features smaller than, at best, 3600 square meters (approximately 0.9 Acre). Steep slopes of length less than DEM or map resolution have the potential to impact the pipeline but are missed by this analysis. Furthermore, by relying on topographic maps, maximum slope gradients are systematically underestimated (Benda et. al. 1997); thus, the risk of slope failure is underestimated.

The analysis appears to exclude slopes less than 100-ft. All the landslide hazards listed in Table 2.15-4 are for slopes greater than 100-ft. If slopes less than 100-ft are excluded, it would undoubtedly lead to an underestimation of risk.

The evaluation of groundwater conditions is not explained. Groundwater levels, and their range of fluctuation, are important hillslope stability variables. Often this information is obtained in the field. Yet, it is not explained how this information was obtained. This is very important because the failure to consider perched groundwater and local variations in depth to groundwater is likely to greatly understate landslide risk. The aquifer section of this report discusses in more detail the failure of the Application to address shallow groundwater.

2.4.4 STEP 3, IDENTIFY LANDSLIDE PROCESSES, SENSITIVE LANDFORMS AND TRIGGERING MECHANISMS

2.4.4.1 Application Presentation

The causes of landslides are briefly described in the Application (p. 2.15-22). Landslide processes are included as part of the landslide types identified in Table 2.15-4 (p. 2.15-24). Sensitive landforms are included in the screening criteria, mainly as slope properties.

2.4.4.2 Critique

<u>The methods used were inadequate.</u> In order to properly route the pipeline and design mitigation measures, it is important to have a good understanding of the landslide processes, the land forms (or physical characteristics) prone to landslides, and the triggering mechanisms (what causes landslides to occur or increases their rate of occurrence). The information provided in the Application indicates that an in-depth understanding was not achieved. The literature search, aerial photographic analysis, and field survey did not identify all landslide processes and the land forms they are associated with (e.g., debris flows). Triggering mechanisms and future land impacts (forest fire, earthquake, development, etc.) are not discussed. Consequently, there are locations along the proposed route where landslide hazards exist that are not listed in Table 2.15-4 (p. 2.15-24).

<u>The analysis does not appear to recognize hazards outside the ?-mile wide Astudy area.@</u> As with the actual photographic coverage, or perhaps as a consequence of that coverage, most of the GTMWH maps only show landslide deposits and hazard potential for slope conditions within the study area. A few GTMWH maps (e.g., Atlas Page No. 79) show landslide deposits outside the study area. This can result in the exclusion of high hazard areas, especially for high slopes.

Debris flows are very likely to originate outside the study area and are a potential hazard to the pipeline. They can occur in large portions of the South Fork Snoqualmie River and the upper Yakima River valleys and, possibly, at other locations. Debris flows are often initiated in hollows on slopes greater than 70%. As debris is transported down the channel, erosion (i.e., scour) occurs. The initiation areas tend to be located in areas of convergent topography, on higher portions of the hillslopes, which frequently are outside the study area. Debris flow scour reportedly will occur in lower portions of the channel whose slopes are as low as 15% (Benda et. al. 1997).

Some proposed stream crossings (e.g., Alice Creek, Hall Creek, Harris Creek) have profiles that fit these debris flow scour criteria, but have not been identified in the Application (e.g., GTMWH map 20 and p. 3.1-4). For example, though the old railroad trestle over Hall Creek was destroyed by a debris flow (Judd 1999) (p. 3.4-80, GTMWH Map 19), the proposed pipeline would be buried in the bed of Hall Creek about 1000 ft downstream of the trestle location. The GTMWH Map 19 shows the channel of Hall Creek as having a moderate mass wasting potential. Table 2.15-4 does not list any existing landslide hazards at this location even though the site had Avisual@ and Ashovel@ investigations. Table 2.15-5 lists this location as having a low landslide hazard potential that would be mitigated with drainage. This appears to ignore the likelihood of future debris flows despite the recent debris flow.

It is understandable that geologists and engineers not accustomed to working in mountainous terrain would all but ignore the consequence of debris flows. However, their importance as a landslide process in the Cascades is well known to earth scientists and land managers working in this area. In addition, debris flows in the Cascades are documented in many reports and publications. For stream crossings identified to be at risk from debris flows (e.g., tributaries to the South Fork Snoqualmie River), models, such as the one developed by Benda and Cundy (1990), could be used to identify debris flow trajectories.

2.4.5 STEP 4, IDENTIFY POTENTIAL IMPACTS OF LANDSLIDES ON PIPELINE

2.4.5.1 Application Presentation

The Application has very little discussion on the potential impacts of landslides on the proposed pipeline. For example, in Section 2.15.7.1 (Potential Impacts Due to Mass Wasting) the Application states that A**mass wasting has the potential to adversely impact both construction and operation of the pipeline. Possible impacts include movement of soil into excavations during installation, movement of soil onto the pipeline after installation, and/or loss of foundation support.**@

2.4.5.2 Critique

The potential impact of landslides on the pipeline are greater than reported. The Application assumes the identified landslide hazards are the only ones possible (see Table 2.15-4). The Application has not identified all landslide processes and future trigger mechanisms. As a result, some landslide hazards such as debris flows and creep were not evaluated. The effects of future land impacts (e.g., earthquakes, forest fires, irrigation, development) on landslide frequency and magnitude were not evaluated. Consequently, landslide hazards and the uncertainties associated with landslides are greater than indicated.

A landslide can rupture the pipeline and cause major environmental impacts. Moving soil or rock masses can exert tremendous forces on the pipeline and cause it to rupture, buckle, develop stress fractures, or separate. A rupture can release thousands or even hundreds of thousands of gallons of gasoline, diesel or turbine fuel into the environment and can cause major environmental impacts. The 408,000 gallon Colonial Pipeline diesel spill on the Sugarland Run tributary to the Potomac River is a clear example (U.S. Department of Interior 1998). The flowing petroleum can erode soil, exacerbating the slide. If gasoline is released, a major fire or explosion could occur. Slow leaks, if undetected, can also cause large impacts. The Application understates the hazard posed by landslides by implying the impact will

only occur to the pipeline. Furthermore, the Application does not address a course of action for upgrading or rerouting the pipeline if a potential or actual landslide hazard develops after the pipeline is built.

2.4.6 STEP 5, IDENTIFY POTENTIAL IMPACTS OF CONSTRUCTION, OPERATION, MAINTENANCE, AND DECOMMISSIONING OF THE PIPELINE ON LANDSLIDES

2.4.6.1 Application Presentation

The Application does not appear to address the issue of the potential impacts of construction, operation, maintenance, and decommissioning of the pipeline on landslides.

2.4.6.2 Critique

<u>The Application fails to note that the proposed pipeline itself could cause a landslide.</u> Pipeline activities (e.g., clearing the corridor, trenching, installing a pipe, backfilling, and traffic associated with corridor use and maintenance, etc.) will affect processes related to slope stability. Permanent tree removal will reduce rainfall interception, reduce evapotranspiration, increase rates of snowmelt (due to increased exposure to wind), and decrease root-reinforced soil strength (Ziemer 1981). Decreases in vegetation in the corridor will lead to increases in soil moisture. If the soil surface becomes compacted due to traffic and/or vegetation loss occurs, runoff will increase. Grading the corridor and certain Business Management Practices (BMPs) (such as dikes and swales as mentioned on p. 1.4-4) will alter hillslope gradient and drainage patterns. The pipeline and its backfill will change shallow groundwater flow. These changes, many of which are not discussed in the Application, are likely to increase landslide rates on marginally stable slopes

For example, pipeline construction is expected to increase the rate of landslides at Peoples Creek (Crossing 15) and Cherry Creek (Crossing 20), where shallow rapid landslides were observed (Application Table 2.15-4). In addition, landslides are much more likely at locations like Griffin Creek (Crossing 28; Weyerhaeuser 1995), Humpback Creek (Crossing 78), and Olallie Creek (Crossing 83), where trees still exist, but will be removed.

Deep-seated failures were identified at three locations west of Snoqualmie Pass: Cherry Creek (Crossing 20), the Tolt River (Crossing 27), and along the South Fork Snoqualmie (Crossings 59 B 61). Pipeline construction on these deep-seated failures can alter drainage patterns and decrease their stability. Drainage patterns may naturally shift due to slump movement, also increasing slide activity. Trench excavation can sever strong soil and rock layers, causing a reduction in shearing resistance and an increase in slide potential.

Some of the deficiencies in the Application were identified in the DEIS. The DEIS (p. 3-28) identified potential impacts of the pipeline on landslides including channeling of groundwater and/or surface water along trenches into unstable slopes. The DEIS (p. 3-22) also correctly identifies situations that could cause mass wasting to occur during construction. For example, undermining the toe of an unstable slope or placing soil at the top of an unstable slope could cause slope movements.

Landslide impacts associated with pipeline abandonment/decommissioning were not evaluated. Landslides, a natural hillslope process, will occur along the pipeline corridor after the pipeline is no longer in use. If the pipeline is left in place, it may increase the size and destructiveness of landslides. Pipe sections may become incorporated into a landslide, contributing to its destructive forces and ending up in streams. If fuel is in the pipeline, it may be released during a landslide, mix with mud and water, and end up in a stream. For these and other reasons discussed in this report, it is important to develop a procedure and clarify the responsibility for pipeline abandonment/decommissioning.

2.4.7 STEP 6, REVIEW COUNTY AND LOCAL ORDINANCES FOR POTENTIAL SCREENING CRITERIA

2.4.7.1 Application Presentation

The Application summarizes permits and regulations in Section 1.6 APertinent Federal, State and Local Regulations.@ The discussion in the Application indicates some of these regulations are related to steep slopes, sensitive areas, critical areas, and geologically hazardous areas along the proposed route. However, the specific applicability of these ordinances to identifying landslide hazard areas, the impacts of landslides on the pipeline, and the resulting impacts on the environment are generally not discussed.

2.4.7.2 Critique

<u>The Application fails to address significant requirements of local ordinances with respect to landslide hazards.</u> The Application provides neither descriptions or locations of landslide hazards according to local ordinances, nor specific discussions on how these hazards would be addressed. A few examples follow:

<u>King County</u> - King County Code (21A.24.280) describes development standards and permitted alterations of landslide hazard areas. These include:

Requiring buffers around landslide hazard areas and setbacks around slopes over 40% grade or 200 ft in height

Prohibiting removal of any vegetation from landslide hazard areas

Exempting utility corridors, if a special study shows that such alteration will not subject the area to the risk of landslide or erosion.

The Application states AOPL will coordinate activities with King County and EFSEC to ensure, to the extent feasible, the King County development standards are incorporated into the pipeline design features.@ This wording suggests the requirements of King County Code may not be met. For example, there is no indication OPL will apply for an exemption to justify removal of vegetation.

<u>Snohomish County</u> - Snohomish County Code (32.10.110 (25) defines a Alandslide hazard area@ as one that is potentially subject to mass earth movement based on a combination of geologic, topographic, and hydrologic factors, with a vertical height of 10-ft or more. These include (for example) the following:

Areas of historic landslides as evidenced by landslide deposits, avalanche tracks, and areas susceptible to basal undercutting by streams, rivers and waves

Areas with slopes greater than 15% grade that intersect geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock and which contain springs or groundwater seeps

Areas located in a canyon or an active alluvial fan, susceptible to inundation by debris flows or catastrophic flooding.

The Application (p. 1.6-17) states that AOPL has determined that the proposed pipeline and pump station is in conformance with existing zoning regulations. The application identifies critical areas and describes potential impacts and mitigation measures.@ Despite this statement, it appears that the Application has not

Aidentified critical areas@ according to county criteria; none of the screening criteria used (see p. 2.15-23) appear to consider vertical heights as low as 10-ft, alluvial fans, or slopes approaching 15%.

<u>Grant County</u> - The Grant County Resource Lands and Critical Areas Ordinance definition of landslide hazard areas is broad enough that landslide hazards are probably within the proposed pipeline corridor. Included as landslide hazard areas are active alluvial fans subject to debris flows, slopes greater than 40% grade and over 10-ft of vertical relief, and slopes parallel or sub-parallel to planes of weakness. Special site analysis and mitigation is required for development in landslide hazard areas. The Application (p. 1.6-21) states ABased on available data, OPL has identified potential critical areas in this Application.@ Despite this statement, it appears that the Application has not Aidentified potential critical areas@ according to county criteria; none of the screening criteria used (see p. 2.15-23) appear to consider vertical heights as low as 10-ft, alluvial fans with debris flows, or slopes parallel or sub-parallel to planes of weakness.

<u>Adams County</u> - Adams County Code defines landslide hazard areas as those potentially subject to landslides based on a combination of geologic, topographic, and hydrological factors. They include any areas susceptible because of any combination of bedrock, soil, slope (gradient), slope aspect, structure, hydrology, or other factors. For example, slopes greater than 80% gradient and subject to rockfall during seismic shaking, active alluvial fans subject to debris flows, slopes that are parallel or sub-parallel to planes of weakness in subsurface materials are potential landslide hazards under Adams County Code. County policy requires a project to establish: whether the project is located in a geologically hazardous area, the potential the project may have on the geologic hazard, and the impact the geologic hazard may have on the project. The Application (p. 1.6-22) states that AOPL has identified potential critical areas in the pipeline corridor.@ Despite this statement, it appears that the Application has not Aidentified potential critical areas@ according to the county criteria; none of the screening criteria used (see p. 2.15-23) appear to specifically consider seismic shaking, alluvial fans with debris flows, or slopes parallel or sub-parallel to planes of weakness.

2.4.8 STEP 7, REVIEW PUBLISHED SCREENING METHODS

2.4.8.1 Application Presentation

The Application does not discuss screening methods other than the one employed that could be used to identify or evaluate landslide hazards.

2.4.8.2 Critique

Better methods for evaluating landslide hazards exist but were not considered. There are many methods for evaluating landslide hazards. Soeters and Van Westen (1996) review some of these methods and classify them into inventory methods, heuristic analysis, statistical analysis and deterministic analysis.

There are also probabilistic methods (e.g., Hammond et. al. 1992) and process-based modeling methods (e.g., Dietrich and others 1995). The model of Dietrich and others (1995) is useful for evaluating where shallow landslides would occur. The model is applicable to unchannelled hillslope areas mantled by colluvium and underlain by mechanically strong bedrock. It determines the thickness of colluvium, the degree of soil saturation (due to rainfall), the effects of root strength, and uses the infinite slope stability model to predict where landslide hazards are located. The model predictions are particularly useful for identifying potential debris flow initiation sites and evaluating the effects that tree removal would have on slope stability in the proposed corridor. A preliminary evaluation of a portion of the proposed route using this model is shown on the attached map.

One screening method that should have been considered is a risk analysis. Using this approach, a landslide hazard is defined as the calculated probability of slope failure, and the risk is defined as the socioeconomic consequences of slope failure. Once the operating period of the pipeline is defined, probability of slope failure could be calculated for different landforms, factoring in long-recurrence triggering events such as forest fires, storm events, tree harvest, etc. By identifying the impacted resources (fisheries, groundwater, habitat, etc.) the risks could be evaluated and optimized for different pipeline routes and different mitigation measures.

Other landslide hazard evaluation methods can be used to check the accuracy of the method used. The accuracy of the landslide hazard assessment presented in the Application (Table 2.15-5) should be checked by plotting the predicted hazard areas on landslide hazard maps prepared by other methods, such as previous landslide hazard analysis like the ones performed for the previously referenced watershed analyses.

2.4.9 STEP 8, ESTABLISH UNAMBIGUOUS LANDSLIDE HAZARD SCREENING CRITERIA

2.4.9.1 Application Presentation

The screening process that developed the landslide inventory, as reported on page 2.15-23, started with reviewing aerial photographs, geology, and topography. Then field reconnaissance was conducted to obtain more information on selected sites. The potential for slope failure and impact on the pipeline reportedly was evaluated using the slope angle, soil and rock characteristics, and groundwater conditions. The Application (p. 2.15-23) states that landslide processes less than 3-ft deep will not significantly affect the pipeline because the pipeline will be buried deeper. The manner in which the data were evaluated is not described in the Application. The screening process, although not clearly explained, was completed by devising an Aimpact potential@ scheme to rank hazards as outlined below:

> Low impact potential was assigned to slopes less than 15% because they Awere considered stable.@
>
> Moderate impact potential was assigned to slopes between 15% and 30% Aand believed stable under normal conditions, but with potential for failure if disturbed without using proper engineering practices.@
>
> High impact potential was assigned to Aslopes in areas with geologic evidence of slope instability, such as slopes in excess of 30% or known areas of inactive slope failures, or have soil/rock types susceptible to failure which require geologic assessment prior to development. In addition, unstable land as evidenced by recent or active slope failure and generally incapable of accommodating development without increasing stability was given a high impact potential.@

The results are displayed on the GTMWH Atlas maps (Appendix B). In addition, Table 2.15-4 (Mass Wasting Inventory) includes the moderate and high impact potential areas identified in the screening process. The text at the bottom of page 2.15-23 states that the inventory in Table 2.15-4 was based on slope and geologic units. Inconsistent with this, however, is the text in the middle of the same page that states groundwater conditions were also considered. Table 2.15-4 does not provide information on groundwater conditions.

Landslide deposits are discussed in Section 3.1.3 under Nature of Foundation Materials. The Application (pp. 3.1-4 to 10) discusses locations of the landslide deposits shown in the GTMWH Atlas.

2.4.9.2 Critique

<u>The screening method described in the Application for designating landslide hazard potential is not well explained and, apparently, not a standard method.</u> The method used to develop the landslide inventory appears to be fairly complex, yet, it is so poorly explained that the reviewer cannot understand what was actually done. For example, it is not clear if a designation of high impact potential occurs when one, all, or some unspecified combination of the listed conditions are met. If the intent is that only one condition be met, the approach is a cautious one. If it is necessary to meet all the conditions, the approach is very risky. The text does not cite other publications to show that the method has been employed successfully elsewhere.

It is not clear how the moderate and high hazard areas shown on the GTMWH Maps (Appendix B) were determined and why many hazard areas shown on the maps are not included in the landslide inventory (Table 2.15-4). For example, GTMWH Map 9 displays moderate and high landslide hazard areas on the proposed route that are not included on Table 2.15-4. Why?

2.4.10 STEP 9, FILL IN DATA GAPS BY CONDUCTING LIMITED SCOPE INVESTIGATIONS

2.4.10.1 Application Presentation

The Application (p. 2.15-23) states Asubsequent field and aerial reconnaissance aerial photographic interpretation and field investigations were used to refine the inventory to determine the need for protective measures@ (sic). Areas along the route that were visited are listed in Table 2.15-4.

2.4.10.2 Critique

The Application=s description of what was done is too vague. It is not clear what additional information was obtained and how it was obtained. Furthermore, it is not clear what additional informational needs were considered, but for some reason rejected. The Applicant should produce and cite reports that explain the methods and should summarize the investigation findings.

2.4.11 STEP 10, ESTABLISH AN UNAMBIGUOUS LANDSLIDE HAZARD RATING BASED ON CURRENT AND POTENTIAL FUTURE CONDITIONS

2.4.11.1 Application Presentation

The Application Table 2.15-5 (p. 2.15-28) summarizes the landslide hazard assessment along the proposed corridor. The rating method was the final step in a three-step process that consisted of: (a) screening, (b) additional data gathering, and (c) landslide hazard rating with selection of protective measures. The first two steps resulted in the landslide inventory (Table 2.15-4) and the last step resulted in the landslide hazard assessment (Table 2.15-5).

The landslide hazard assessment was reportedly accomplished by devising an A**impact potential**@ **rating scheme** A**to select protective measures to minimize inputs due to mass wasting**@ **(see pp. 2.15-26 to 27). These ratings are applied to the sites identified in the landslide inventory when a high-moderate-low rating system is used. However, the rating criteria are different from those used in developing the landslide inventory. For example, Moderate Impact Potential in the Mass Wasting Hazard Assessment results from:**

A**Prehistoric landslide activity with no evidence of recent movement.**@ **(The reviewer should note that prehistoric typically refers to written records, so this is very recent in geologic terms.)**

A**Soil slopes between 1H:1V and 3H:1V**@ **(i.e., between 33 and 100%). The reviewer should note the screening-level criteria included slopes between 15% and 30% in the moderate category and slopes steeper than 30% in the high impact potential category, according to the criteria used in developing the landslide inventories.**

A**Rock slopes steeper than 1H:1V**@ **(i.e., steeper than 100%).**

A**Shallow groundwater**@ **(< 5 ft below ground surface).**

A**Flat gradient drainage at slope toe**@**.**

2.4.11.2 Critique

<u>The type of landslide analysis method used in the Application will not adequately define landslide risk.</u> As with the screening criteria, the text does not explain whether one, some, or all of the criteria listed above must apply, and why these criteria are different from the screening criteria. The results of this ranking are summarized in Table 2.15-5 (Mass Wasting Hazard Assessment). Apparently, each of the locations identified in the initial screening were evaluated for both shallow and deep failure hazard potential and are listed in Table 2.15-5. The text (pp. 2.15-26 and 27) states that sites with low impact potential will not be studied further; sites with moderate impact potential may be studied further, but A**only if they exhibit factors judged significant during construction**@**; and sites with high impact potential will be studied in detail during final design phase.**

This is significant because slopes that are classified as having low impact potential are reported to require no further study. This may be unsafe. For example, one of the criteria that results in a classification of low impact potential is a slope angle up to 33%. Yet over half of the landslides (both dormant and active) listed in Table 2.15-4 have slope angles equal to or less than 33% (i.e., equal to or greater than 3H:1V). Furthermore, waiting until construction to obtain information pivotal to a determination of risk for moderate impact slopes can result in unidentified and unmitigated risks.

<u>The rating system used is unique and ambiguous.</u> The rating system appears to be unique to this project and not based on rating systems used successfully elsewhere. If it has been, its previous use is not referenced in the Application. The method is ambiguous because it does not explain how to apply the various criteria to determine the ranking.

The terminology used to describe the landslide hazards is inconsistent and confusing. For example, the Application text (pp. 2.17-23 and 27) uses the term A**impact potential**@ **for both the screening method rating and the protective measures rating systems. Table 2.15-5 uses the term** A**hazard potential,**@ **while the GTMWH maps show** A**mass wasting potential.**@

<u>The limitations of the method used are not described.</u> It is good engineering practice to state the limitations of a landslide hazard evaluation. This is especially important when the methods used are not conventional and the potential impacts from slope failure are high.

<u>No explanation is provided where the landslide hazard rating system differs from county and local codes.</u> As previously discussed, local agencies have developed methods for identifying potential landslide hazards in their municipalities. The

Application, however, does not discuss local landslide hazard criteria or whether the method used by the applicant is equal to or better than those described in local codes.

The Application fails to take future impacts to the land into account. Given the potentially long life of this project (see Application p. 7.3-2), it is important to examine future changes in geotechnical conditions that can cause landslides. Future land impacts such as earthquakes, forest fire, irrigation, and land development could have major effects on processes that affect slope stability. The Application has not identified these future impacts on slope stability. Similarly, landslides could occur in irrigation areas due to slowly rising water tables. Since irrigation is common along the pipeline corridor in central and eastern Washington, it is important to examine the potential for slides triggered by raising water tables.

Neglecting the effects of earthquakes on landslides is a serious deficiency of the Application. According to Wieczorek (1996), strong ground shaking during earthquakes has triggered landslides in many different topographic and geologic settings. Rock falls, soil slides, and rock slides from steep slopes, involving relatively thin or shallow disaggregated soil or rock, or both, have been the most abundant types of landslides triggered by historical earthquakes. Earth spreads, earth slumps, earth-block slides, and earth avalanches on gentler slopes have also been abundant. The Magnitude 7.1 Loma Prieta (California) earthquake, of October 17, 1989, triggered an estimated 2,000 to 4,000 rock, earth, and debris falls and slides. Besides causing landslides that rupture the pipeline, an earthquake is also likely to cause landslides that block roads, damage power lines, and disrupt communications, thus slowing response time.

2.4.12 STEP 11, FOR ACTIVE AND DORMANT LANDSLIDE AREAS, ESTABLISH PROBABLE CAUSE OF LANDSLIDE ACTIVITY AND TRIGGERING MECHANISMS FOR FUTURE MOVEMENT

2.4.12.1 Application Presentation

The Application (p. 2.25-23) states that high impact potential was assigned to inactive and active slope failures in the screening process. For selecting protective measures (p. 2.15-26), high impact potential was assigned only to recent landslide activity and moderate impact potential was assigned to pre-historic landslide activity. Somewhat inconsistently, the text (p.2.15-27) states that a high impact potential was assigned to Asignificant pre-historic landslides which have a high potential for future re-activation.@

2.4.12.2 Critique

<u>It is not clear if these high hazard areas were correctly identified.</u> Active and dormant slides represent very high landslide hazards because a failure surface is known to exist. The probability of future movement must be determined by evaluating these landslides and their triggering mechanisms. Nearby landscape features that resemble the known landslide site must also be evaluated for the probability of failure. For example, at the Swauk Creek crossing (GTMWH map 43) the proposed route skirts landslide deposits on the southeast slope of Lookout Mountain. Geologic mapping by Tabor and others (1982) shows that slopes on most sides of Lookout Mountain, except where the proposed route is, are covered with landslide deposits. The Application (Table 2.15-5) assigns a high hazard potential to this location and lists Aavoidance@ as the mitigation measure. However, it appears that the high hazard potential, applies only to the landslide deposits that were avoided. If so, what is the hazard potential of the slope the pipeline would be located on? The text does not explain why the other slopes of Lookout Mountain failed and why the one portion of Lookout Mountain the pipeline would be located on will not fail. As another example, GTMWH map 38 shows the pipeline crossing landslide deposits and a dormant landslide. Table 2.15-5 assigns this area moderate hazard potential but no explanation is provided. GTMWH map 38 may have an error because these landslide deposits are shown to have Alow mass wasting potential.@

2.4.13 STEP 12, FOR HIGH HAZARD AREAS, EITHER REROUTE PIPELINE OR CONDUCT A COMPREHENSIVE INVESTIGATION

2.4.13.1 Application Presentation

The Application (p. 2.15-26) states that Aduring final design phase prior to construction, sites identified as having a potential for a high level of impact for future mass wasting due to the above factors will be studied in additional detail. These studies would include a site-specific geotechnical investigation and slope stability analyses to determine the most likely mode of failure and the factor against failureYPotential mitigation options could include improving soil strength properties, adding structural elements to externally retain slope, changing the geometry of the slope, or rerouting the pipeline."

2.4.13.2 Critique

<u>The Application does not commit to any specific scope of investigation.</u> The Application does indicate further investigations are warranted, but these will be done during final design phase (i.e., after the project is approved) and they will provide Aadditional detail.@ However, it is important to identify a design factor of safety (based on a specific method of analysis) prior to project approval. The factor of safety proposed by the applicant will be an indicator of the importance placed on protection of the environment. Without this information, it is impossible to identify the risk at this stage of the project.

2.4.14 STEP 13, FOR MODERATE HAZARD AREAS, PERFORM STEP 12 OR IDENTIFY REASONS NOT TO

2.4.14.1 Application Presentation

The Application (p. 2.15-27) states that Asites classified as having a moderate risk for future mass wasting may be studied further, but only if they exhibit factors that are judged to be significant during construction. Additional investigations for sites in this category would include limited characterization of the surface and subsurface conditions and limited slope stability analyses. It is anticipated that these additional studies would confirm that no mitigation of these slopes would be required.@

2.4.14.2 Critique

<u>The Application does not explain what conditions must be met in order to justify additional study.</u> Besides not being clear on what Asignificant factors@ are, the Application is highly ambiguous on whether additional study would be done if the Afactors@ are present. Since further study would occur during construction, it is likely to be very limited in scope in order not to affect the construction schedule. Furthermore, because of the deficiencies in the landslide analysis already identified, the implication of the last sentence in the paragraph above is that the applicant will seek to confirm what is not known.

2.4.15 STEP 14, DEVELOP APPROPRIATE ENGINEERING DESIGNS AND MITIGATION

2.4.15.1 Application Presentation

The Application lists mitigation measures for the identified landslide hazards in Table 2.15-5 (p. 2.15-28). The mitigation measures listed are avoidance, strain gage

pipe, long-term monitoring, drainage, buttress, increase burial depth, and additional exploration for design. The Application text (pp. 2.15-29 to 30) briefly discusses these measures plus two additional measures, reorientation of pipeline against slope and regrade. The Application (p. 2.15-27) states that final decision of mitigation measures will follow completion of detailed site investigation.

2.4.15.2 Critique

Project reviewers are required to approve a project where key information is missing. The Application requires the reviewer to approve tentative landslide mitigation concepts without the benefit of site-specific data. Only general information on the landslide hazard locations is summarized in Tables 2.15-4 and 2.15-5, the maps in Appendix B, and scattered in different parts of the text. Consequently, the reviewer cannot evaluate the feasibility of the tentative mitigation concepts.

The difficulties of mitigating landslide hazard areas are underestimated. Following are some examples of the difficulties that will be encountered in stabilizing some of the landslide areas along the proposed route. The issues surrounding stabilizing these areas result in more questions than answers. In addition, the discussion in the Application fails to address the new risks and hazards associated with the proposed mitigations.

Peoples Creek - The potential for shallow-rapid landslides at Peoples Creek (stream crossing 15) is high (Table 2.15-4, p. 2.15-24). One potential reason for the observed active landslide is the loss of root strength from past tree removal. The steep slopes at the site will make mitigation difficult. The DEIS (p. 3-30) states that AY**it is very unlikely that backfill can be placed and suitably compacted on 60 degree slopes.**@ **Without compaction and vegetation with substantial root masses (e.g., trees), it is highly likely the slope will erode or fail. Mitigation measures suggested at this site include burying the pipeline deeper, adding drainage, and buttressing the toe of the slope. These mitigation measures present problems themselves. How will deeper burial be accomplished? Will excavation intercept soil or rock layers that will control slope strength or groundwater seepage? Would the pipeline have to be trenched into andesite bedrock and require blasting? Would blasting open fractures, thus leading to greater environmental impacts if a leak were to occur? Peoples Creek is at the toe of the steep slope, therefore, the buttress would have to be placed in the creek. How will buttress construction be accomplished without constricting the channel, leading to the greater likelihood of stream scour and lateral migration? The potential impacts to fisheries and wildlife associated with buttress construction must be addressed. The type, location, and effectiveness of drainage**

at this site is unclear.

<u>Cherry</u> <u>Creek</u> - Mitigation measures proposed for Cherry Creek include increasing burial depth, installing drainage, installing a buttress, installing diversion berms and long-term monitoring. Because active and deep-seated failures may be present at this site, it is uncertain if increased burial depth will provide adequate mitigation. Since the stream flows along the toe of the slope, the proposed buttress would have to be placed in the stream.

The Application does not adequately describe the difficulties posed by conditions at this site. Backfill compaction will be difficult on the steep slopes. Steep slopes, groundwater seepage, erosion, and proximity to the channel make it virtually impossible to prevent sediment from reaching Cherry Creek. The type and location of the drainage used on this site has yet to be determined and its effectiveness is uncertain. The DEIS (p. 3-31) recognizes that mitigation measures proposed for this site do not serve to stabilize the hillside or appreciably reduce the potential for damaging the pipeline in the event of a landslide.

<u>Tolt</u> <u>River</u> - The mitigations proposed in the Application (Table 2.15-5) for this location include drainage, additional subsurface exploration, long-term monitoring, and pipe strain gage. The effectiveness of these mitigation measures on a possible deep-seated failure is uncertain since the locations of potential failure surfaces is currently unknown. Other proposed mitigation includes monitoring the slope and the groundwater levels. The problem is these mitigation measures do not stabilize landslides. As discussed below, the advantage they do offer of increased warning time is contingent on other factors. Another complication at this location is the potential for changes in land use to affect groundwater conditions and the stability of the deep seated slide. An assessment of the impact of land use on the deep-seated failures at this location is appropriate. Rerouting the pipeline away from this location may be the only viable mitigation option. The feasibility and alternate route should, therefore, be discussed

2.4.16 STEP 15, PERFORM LONG TERM MONITORING

2.4.16.1 Application Presentation

The Application proposes long-term monitoring as a mitigation measure at three locations identified in the landslide hazard assessment (Table 2.15-5). The text (pp. 2.15-29 and 30) discusses the kinds of monitoring that would be used. The Application states the Afrequency of monitoring to be adjusted according to the weather conditions, but will not be greater than one month. Instruments could be

read manually or connected to a automated data acquisition system@ (sic).

2.4.16.2 Critique

<u>The Application does not discuss the limitations of monitoring.</u> The ability of monitoring to prevent an environmental disaster is limited by certain factors not reasonably discussed in the Application. The greater the amount of warning time, the more likely response efforts will be able to avert a disaster. The greatest amount of warning time would come from a Areal-time@ monitoring system with a programmable logic controller and alarm system. Such a system could determine if readings are within realistic ranges, notify operators when detecting devices are not functioning properly, and determine which combinations of variables, such as groundwater levels and slope movement, are unsafe. Real time systems are being used more and more for monitoring landslide and seismic events. The Application does not indicate that state of the art real-time monitoring would be used.

In order for an environmental disaster to be averted there has to be some way to drain a portion of the pipeline after the operators have been warned and the block valves closed. Otherwise, the fuel trapped in the pipeline will spill if earth movement cannot be stopped. Creation of contingency plans that describe how fuel would be drained from the pipeline and where it would be stored after monitoring equipment detects a slope stability hazard is not discussed in the Application.

2.4.17 SUMMARY AND CONCLUSION

The scope and level of detail of the Application are not adequate to evaluate the risk and environmental impact of landslides on the pipeline, resulting in an understatement of actual landslide risk. The general descriptions of geology and geomorphology are helpful, but insufficient. A proper evaluation of landslide hazards for a project of this scope would include many, if not all, of the 15 steps described above. The Tolt River Crossing and Swauk Creek Crossing Spill Scenarios, presented in another part of this report, clearly show that environmental impacts due to landslides can be very serious. The proposed project should not be approved until a comprehensive landslide evaluation with identified mitigation measures has been performed.

2.5 STREAM SCOUR AND LATERAL EROSION

2.5.1 INTRODUCTION

The pipeline will be particularly vulnerable at stream crossings. The erosive power of the water in the stream channel combined with the erodible nature of channel alluvium make the pipeline susceptible to being undermined or exposed by erosion. Six steps are discussed below that define a comprehensive evaluation of the issues associated with stream scour and lateral erosion.

Obtain information on stream scour and lateral erosion.

Identify potential impacts of stream scour and lateral erosion on pipeline and environment.

Identify methods for evaluating stream scour and lateral erosion.

Identify data needs and collect data.

Develop appropriate engineering design and mitigation measures.

Monitor and Maintain.

The Application presentation is reviewed with reference to these six steps.

2.5.2 STEP 1, OBTAIN INFORMATION ON STREAM SCOUR AND LATERAL EROSION

2.5.2.1 Application Presentation

The Application (Appendix B) relies on West Consultants (1997) and Dames & Moore (1998) for evaluating stream scour for many streams in the project area. West Consultants (p. 3) reportedly reviewed aerial photographs and reports and conducted field studies. Dames & Moore (p. 4) reviewed aerial photographs and maps and reports, and relied on field studies by West Consultants to evaluate conditions at the Columbia River crossing.

For evaluating lateral erosion, floodplain locations and widths, which are summarized in Table 3.3-7, provides limited information. Floodplain widths reportedly were obtained from FEMA. Additional limited information is provided by West Consultants (1997) and Dames & Moore (1998).

2.5.2.2 Critique

Credible information on lateral migration is available that was not used. For lateral erosion hazards (also called channel migration hazards), information exists that was not identified by the applicant (e.g., Perkins 1996; Shannon & Wilson 1991). These reports provide the reviewers with in-depth information on lateral erosion at a few specific locations along the proposed route. Additional information can be obtained by performing a literature search and contacting agencies and land managers.

The Application fails to identify all geomorphic features susceptible to scour and lateral erosion. Alluvial fans are geomorphic features where lateral erosion is likely to occur. Alluvial fans are present along the proposed corridor. For example, the geology and geomorphology section of this report discusses a large alluvial fan north of Ellensburg. Debris flow channels are an example of locations that are periodically scoured by mud and woody debris. Debris flows are discussed in the landslide section of this report. Neither process is addressed in the Application.

The Application also fails to identify locations where channel avulsion is likely to occur. Avulsions are sudden shifts in the location of a stream channel. Stream crossings that have a history of avulsions (such as the Tolt River at the proposed pipeline crossing) should be addressed.

The Application assumes that the stream bed elevation will not change over time. As changes in sediment inputs propagate downstream, the stream bed elevation, channel depth, and channel width can change. The pipeline crosses geomorphic regions that are expected to undergo channel incision (West Consultants 1997, p.11). Consequently, the pipeline burial depth will decrease over time, making it even more vulnerable to scour during flood events.

2.5.3 STEP 2, IDENTIFY POTENTIAL IMPACTS OF STREAM SCOUR AND LATERAL EROSION ON PIPELINE AND ENVIRONMENT

2.5.3.1 Application Presentation

The Application notes that scour and erosion can expose the pipeline. Once exposed, the pipeline may be subject to buoyant forces. The Application does not discuss impacts on the environment.

2.5.3.2 Critique

Potential impacts of scour and lateral erosion on the pipeline and the environment are not identified. There is no clear discussion on how erosion of the stream channel can cause damage to the pipeline and what the resulting impacts to the environment would be. The hazard from buoyancy is mentioned indirectly by discussing the mitigation of encasing the pipeline in concrete. The hazard posed by lateral forces if soil or sediment is eroded away is not discussed and is apparently not incorporated into design and mitigation conditions.

Environmental impacts that result from pipeline ruptures or leaks caused by scour and lateral erosion are not discussed. None of the spill scenarios (Appendix B) postulate a spill caused by stream scour or lateral erosion. This is a significant omission because damage to a pipeline by stream scour or lateral erosion can result in all of the spill directly entering a surface water body.

2.5.4 STEP 3, IDENTIFY METHODS FOR EVALUATING STREAM SCOUR AND LATERAL EROSION

2.5.4.1 Application Presentation

Stream scour was evaluated by methods described in the previously referenced West Consultants and Dames & Moore reports. West Consultants used two methods to evaluate scour analysis. The primary method Aemploys regime equations supported by field measurements for estimation of scour potential. The method is recommended by the Bureau of Reclamation for design of structures, such as a pipeline, that are to be located in a river channel.@ To check the primary method, a second method was used. This Aempirical USGS method was developed from measured scour depths along streams throughout the western United States, including Washington State.@ However, West Consultants did not evaluate scour at the Columbia River crossing.

Dames & Moore=s reports a method for evaluating scour at the Columbia River crossing. For this method, AChannel hydraulics were computed using the U.S. Army Corps of Engineers HEC-RAS standard step backwater computer program. The results of the hydraulic computations Y provided the basis for the scour evaluation using the HEC-6 program.@ Both West Consultants and Dames & Moore evaluated scour assuming a 500-year flood event.

2.5.4.2 Critique

<u>Credible methods exist for evaluating lateral erosion that were not identified.</u> Both empirical and deterministic methods exist for evaluating lateral erosion. Typically the empirical method relies on historical aerial photographs and a field study (e.g., Perkins 1996). The Application does not identify methods for evaluating lateral erosion.

<u>Previous successful applications of the stream scour methods are not provided.</u> West Consultants (p. 2) notes that their same primary scour method identified for use on the Cross Cascade Pipeline was used on a pipeline project in the southwest and no scour problems have occurred since 1992, when the pipeline was built. However, since West Consultants does not discuss how the success of a particular method of analysis will vary with climate, terrain, and hydrologic conditions, it is difficult to evaluate the potential for successful use of the same method on the proposed project.

<u>The scour method relies on assumptions that limit its applicability to the proposed project.</u> Neither of West Consultants (p. 4) scour analysis methods applies to the culverts, bridges, and irrigation canals that support or protect the pipeline. However, scour could impact these structures too. West Consultants notes that the primary method assumes a forest cover factor. Forest cover could be significantly reduced due to timber harvest, forest fire, or disease. The two methods used by West Consultants yielded different results. It is not clear whether one or both methods are wrong. These potential problems are not resolved in the Application.

The primary scour analysis by West Consultants assumes that the hydrology at each crossing location is consistent with the assumptions in the regression equations used. According to West Consultants (p. 3), AIt is noted that although the regression analysis can provide a reasonable approximation of the hydrology, they only account for site-specific characteristics reflected in the involved hydrologic parameters.@ In other words, there may be hydrologic differences that the regression equations do not evaluate. Presumably, the site-specific characteristics not Areflected in the involved hydrologic parameters@ could lead to errors in scour depth calculations. This uncertainty should be resolved.

The Application presents a screening level scour evaluation only. The DEIS (pp. 3-34, 3-172) states that the level of investigation proposed in the Application to evaluate scour and lateral migration potential at most stream crossings would not be adequate to determine sufficiently conservative burial depths for the pipeline along much of the proposed route. The DEIS states that the present day understanding of stream and hillslope processes is limited and it is not feasible to completely eliminate the potential for impacts from stream scour and lateral migration (DEIS, pp. 3-37, 3-173). The DEIS recommends reevaluating the scour potential of steeper gradient streams, including all of those within the Cascades. In addition, the DEIS recommends that scour evaluations consider processes such as headwall migration, debris flows, log jams, flow constrictions, and gully advancement in disturbed streams.

The Application does not discuss other applicable screening criteria. For example, the King County zoning code (21A.24.240) requires pipelines carrying hazardous substances be buried a minimum of 4-ft below the maximum scour depth for a Abase flood.@ The Application does not address how the proposed burial depth of 2-ft below the maximum scour depth based on a 500-year flood compares to the King County criteria.

Scour was only evaluated at 157 of a total of 288 proposed crossings. West Consultants did not evaluate 68 culvert crossings, 9 new and existing bridge crossings, and 49 irrigation canal crossings. In addition, six river crossings were not evaluated by West Consultants. These include the Columbia River, Yakima River, Tolt River, Lower Crab Creek, and Swauk Creek. West Consultants recommended separate studies of the Columbia River because of influences from the dam; the Yakima River because Ait is a large and important waterway that warrants a more detailed study@; the Tolt River because of the high potential for lateral scour and local scour due to large woody debris; Lower Crab Creek because data on the upstream Potholes Reservoir were not available; and Swauk Creek because information reviewed indicates this crossing Ais experiencing significant erosion and is unstable.@

Scour at the Columbia Crossing was evaluated by Dames & Moore.

Scour should be evaluated at all susceptible crossings before project approval.

2.5.5 STEP 4, IDENTIFY DATA NEEDS AND COLLECT DATA

2.5.5.1 Application Presentation

West Consultants and Dames & Moore briefly describe the information reviewed for the scour studies. West Consultants examined aerial photographs, maps, and reports as well as obtained site-specific field data. It is not clear, however, which of the crossings were visited. Dames & Moore used site-specific data on the Columbia River crossing that was obtained by West Consultants and Aavailable information.@ The Application does not discuss the data needs for evaluating lateral erosion.

2.5.5.2 Critique

Site-specific stream crossing plans are needed. The DEIS (p. 3-144) recommends stream crossing plans and specifications for sensitive stream crossings. These plans would include scour depth and lateral erosion estimates. For example, the Columbia River crossing drawings (Application p. 2.14-12; Dames & Moore 1998) should include a cross section showing geology, scour depth, lateral erosion potential, pipeline location, and flood levels.

FEMA floodplains are not sufficient to accurately assess lateral erosion hazards. As previously noted, the Application relies on FEMA-defined floodplains. These floodplains are created by a process that does not evaluate lateral erosion and does not necessarily recognize geomorphic floodplains. For example, a structure located on a terrace above the FEMA floodplain may be subject to damage caused by lateral erosion at the base of the terrace. Also, due to lateral erosion, FEMA maps can rapidly become outdated. It is, therefore, important to field check these maps. The extent to which this was done should be clarified.

The proposed Columbia River crossing needs additional study. The directional drilling method requires starting and ending the tunnel near the river. As noted in the DEIS (p. 3-38), between these locations and the valley walls, the pipeline will potentially be vulnerable to erosion during floods. This risk should be resolved before the project is approved.

Stream scour and lateral erosion at the preferred Columbia River crossing relies, in part, on equilibration of the channel with the dam. Since the Wanapum Dam began operation in 1964, there may not have been a long enough period of time for the channel to equilibrate. For example, the scour depth calculation performed by Dames & Moore assumes a 500-year flood of 530,000 cfs. The largest flood since the dam was built was 350,000 cfs (Dames & Moore, p. 8). This flood caused significant erosion of the west bank. Consequently, the potential for bank erosion should be reevaluated for a 500-year event. This is important because the pipeline will not be buried as deeply under the banks.

Also uncertain are future Columbia River hydrologic conditions. In order to manage salmon stocks more efficiently or for other reasons, river flows and reservoir storage may change in the future. This, in turn, may affect the size and frequency of flood events. The potential impact these changes could have on stream scour and lateral migration should be addressed before project approval.

2.5.6 STEP 5, DEVELOP APPROPRIATE ENGINEERING DESIGN AND MITIGATION MEASURES

2.5.6.1 Application Presentation

The Application (pp. 1.4-16 and 3.3-54) states that the pipeline would be buried below the scour depth across the full width of the floodplain. In contrast, pages 1.4-3, 2.14-4 and 12, 2.15-21, and 3.4-106, and Figures 2.14-2 through B5, neither discuss nor show burial beneath the floodplain. Rather, these pages imply or show burial beneath the active channel only. The Application (p. 2.14-4) states AThe trench will generally be deeper than the normal 5-ft depth in order to place the pipe deeper than the calculated maximum scour depthY Pipeline construction techniques for water crossings assume at least standard burial depths of 4 to 5 ft to avoid exposure from scour. Where high scour velocities are indicated along with erodible bed materials, additional geotechnical investigations for scour depth have been or will be conducted and the pipe will be buried deeper according to the findingsY The crossing method to be used at each sensitive area crossed by the pipeline will be determined using the information available, including field observations, but methods will be verified or refined during alignment and engineering design studies.@

The Application (p. 3.3-54) states AWithin stream valleys with no designated floodplain, field determination of the floodplain width will be completed at each stream crossing either as part of the design phase at the most sensitive stream crossings or during the construction phase.@

2.5.6.2 Critique

The depth of burial is generally not specified and, where it is, it may be insufficient. The depths the pipeline will be buried for the most part are not specified. For example, Section 2.14 (Construction Methodology) does not state the burial depths except for the Columbia Crossing (30-ft, Figure 2.14-5) and the Yakima River (6-ft, p. 2.14-22). The report by West Consultants (1992) in Appendix B of the Application provides screening level estimates of scour depths for some of the crossings. However, the Application text does not reference the depths in West Consultants (1997). In the case of the Yakima River crossing (crossing number 147), West Consultants (1997, p. 8) indicates that even with 7-ft burial, this location Awarrants additional study.@ Why the Application indicates a 6-ft burial depth and what additional study was accomplished, if any, is not addressed. Important design issues such as these should be resolved.

The Application does not consistently state where the pipeline will be buried beneath the scour depth. The text and figures in the Application do not make clear where burial beneath the scour depth would occur. Even where the text states that burial will be beneath the flood plain, it is not clear which flood plain (e.g., 50-yr, 100-yr, 500-yr, geomorphic flood plain, FEMA flood plain, etc).

In order to properly protect the pipeline from stream scour and lateral erosion, the project life must be defined. As discussed in other parts of this report, a proper engineering design requires the life of the project to be defined. The scour analyses performed by West Consultant and Dames & Moore assume 500-yr flood events. If the life of the pipeline is 50 years (as assumed by West Consultants 1997, p.2), then there would be about a 10% chance of experiencing the design flood. The Application (p. 7.3-2) describes the life as Aindefinite.@ This implies certain failure.

2.5.7 STEP 6, MONITORING AND MAINTENANCE

2.5.7.1 Application Presentation

The Application (p. 1.4-12) states Apotential geologic hazard areas will be further mapped as part of the >as built= survey and these areas will be visually inspected as part of the routine inspection program.@ The Application (p. 1.4-10) discusses regular aerial monitoring and states (p. 1.4-16) Awater crossings will be surveyed for bottom contours to ensure adequate soil depth over the pipeline is maintained.@

2.5.7.2 Critique

Monitoring is needed because the stream bed will change over time. As previously discussed, geomorphic processes will cause the stream bed to move vertically and horizontally. Therefore, it is important that stream channels are reevaluated both periodically and following major storms to confirm adequate burial remains. The DEIS (p. 3-145, 3-173) recommends monitoring at each crossing to minimize risk of damage from scour and lateral erosion. Monitoring should include the following: survey the elevations of the pipeline and channel profiles (cross and longitudinal sections) in the scour and lateral erosion hazard areas. Additionally use scour chain monitoring in sensitive areas: data analysis following monitoring; develop a contingency plan for taking appropriate steps when scour and erosion reaches predetermined threshold values. The method referred to in the Application is too vague to Aensure adequate soil depth over the pipeline is maintained.@

Maintenance is required. The active nature of stream channels makes erosion and channel change inevitable. Consequently, maintenance will be needed at crossing locations. A maintenance plan should be developed that specifies the scope of maintenance at all stream crossings that are potentially vulnerable to stream scour and lateral erosion.

2.6 EROSION

2.6.1 INTRODUCTION

Erosion associated with the proposed project is important because of the negative impacts it can have on the environment as well as its potential for causing loss of foundation support for the pipeline. The evaluation of erosion hazards and explanation of mitigating actions presented in the Application are not sufficiently comprehensive given the potential impacts of the proposed project. A comprehensive evaluation of erosion hazards and mitigating actions should include the steps listed below.

Step 1: Identify potential erosion impacts during construction, operation and decommissioning

Step 2: Review literature and contact agencies and land managers to obtain regional data

Step 3: Review county and local ordinances and published erosion screening methods

Step 4: Identify erosion hazard areas

Step 5: Identify data needs and obtain site-specific data

Step 6: Develop appropriate design, construction and mitigation methods

Step 7: Evaluate the potential impacts caused by erosion and sedimentation

Step 8: Perform monitoring and maintenance.

2.6.2 STEP 1, IDENTIFY POTENTIAL EROSION IMPACTS DURING CONSTRUCTION, OPERATION, MAINTENANCE, AND DECOMMISSIONING

2.6.2.1 Application Presentation

The Application discusses erosion caused by construction in Sections 1.4 (Mitigation Measures), 2.3 (Construction on Site), 2.10 (Surface-Water Runoff and Erosion Control, especially Table 2.10-2), 2.14 (Construction Methodology, especially for stream crossings), 3.1 (Earth), and 3.4 (Plants and Animals). Erosion caused by construction is also indirectly referenced wherever BMPs and other erosion mitigation measures are discussed in these sections. There is no discussion of erosion caused by operation or decommissioning of the proposed pipeline in the Application.

2.6.2.2 Critique

Pipeline operation will cause erosion. The Application assumes that all erosion will occur during construction. However, repairs and maintenance will be needed and the corridor will be used for inspections and other purposes. The longer the pipeline is in use, the more traffic there will be and the more the pipeline will have to be excavated and repaired. The Application fails to consider whether repair of the pipeline will be allowed during periods when construction is typically not appropriate or allowed. For example, more erosion will occur if repairs have to be made during periods of heavy rain and more environmental impacts will occur if repairs are made near a creek during the time fish are spawning.

Traffic will occur with inspections and maintenance. In addition, parts of the corridor will probably be subjected to unauthorized use by people, vehicles, horses and cattle. The Application (p. 3.4-46) acknowledges that the corridor will provide increased access to the public. Use of the corridor will damage vegetation, compact the soil surface and dislodge soil particles, possibly leading to the formation of gullies. When this happens, erosion will occur. Use the corridor to cross streams will cause bank and bed erosion. Erosion near streams will deliver sediment and is likely to cause adverse environmental impacts.

Key variables affecting erosion rates and triggering mechanisms are not identified. In order to effectively prevent or reduce erosion and control sedimentation, it is important to understand the underlying processes. For example, the main variables affecting road erosion on the west side of the divide are rainfall, right-of-way geometry, and traffic. On the drier east side, wind is also important. The mitigation measures (Application p. 3.1-22 through-24) do not mention minimizing traffic, especially traffic during wet or very dry and windy weather. Similarly, wind control and dust formation are not sufficiently discussed.

Public/private works that could be affected by sedimentation are not identified. Erosion-derived sediment from the project will contribute to cumulative impacts on public and private works. Sediment enters surface water intake structures and damages conveyance structures, control structures, instruments and pumps. Sediment reduces the quality of water used for industrial purposes (e.g., cooling), domestic drinking water, livestock watering and irrigation. Sediment deposits in reservoirs and navigable portions of rivers may require costly dredging. Sediment accumulations in stream channels contribute to blockages and scour near bridges and culverts and can lead to increases in channel width and bank erosion.

Erosion could damage the pipeline. Loss of foundation support could lead to a pipeline spill. The DEIS (pp. 3-27 and 28) states that erosion of trench backfill, particularly on steep slopes, could result in breakage of the pipeline during operation. Gradual erosion by flowing water could undermine the pipeline. For example, this could happen where the pipeline passes within about 100-ft of the South Fork Snoqualmie River and the soils have a high erosion potential (see STEH Map 17). In farming areas, water and wind erosion has been known to reduce the soil cover such that the pipeline would become susceptible to third party damage by farm machinery. These erosion impacts are not addressed in the Application.

Erosion associated with pipeline decommissioning is not addressed. Pipeline use will cease at some time. The Application does not discuss this eventuality. Thus, it is not known whether the pipeline will be removed, abandoned in place or some combination of both methods. Similarly, the methods used to abandon or remove the pipe are not discussed nor are the requirements and responsibility for restoration and post removal care. If there are decommissioning activities on the corridor that create traffic or require digging, there will be erosion and sedimentation.

2.6.3 STEP 2, REVIEW LITERATURE AND CONTACT AGENCIES AND LAND MANAGERS TO OBTAIN REGIONAL DATA

2.6.3.1 Application Presentation

The Application (p. 3.1-33) states that the assessment of erosion hazards is Aprincipally based on the erosion potential specified for the surficial soils determined by the NRCS and DNR.@ The Application (Section 1.5) does not indicate that information on sediment sources and sediment transport in the basins of interest was researched or that land managers or agency personnel were contacted.

2.6.3.2 Critique

The literature review was inadequate. In addition to NRCS (Natural Resources Conservation Service, formerly the Soil Conservation Service) and DNR (Washington State Department of Natural Resources) publications, other publications are useful. For example, erosion processes and factors affecting erosion are covered in Ecology=s Stormwater Management Manual for the Puget Sound Basin (Washington State Department of Ecology 1992, Sections II-1.2 and 1.3).

Watershed analyses and sediment budget studies are other sources of information for road and hillslope hazard areas, erosion rates and triggering mechanisms. Watershed analyses identify portions of stream channels as well as public works that may be impacted by sediment inputs (e.g., Weyerhaeuser Company 1993, 1995). Information describing sediment sources, sediment production and sediment transport in some of the basins of interest is contained in Nelson 1971; Dunne 1980; Booth and others 1991; Dunne 1988; and, Weyerhaeuser Company 1993, 1995. The Bureau of Reclamation, because it operates dams and irrigation canals, may have sediment information for the upper Yakima basin. Sediment production information could also be obtained from basins similar to the ones the pipeline crosses, and applied to this project (e.g., Paulson 1997).

2.6.4 STEP 3, REVIEW COUNTY AND LOCAL ORDINANCES AND PUBLISHED EROSION SCREENING METHODS

2.6.4.1 Application Presentation

The Application summarizes permits and regulations in Section 1.6 (Pertinent Federal, State and Local Regulations). The discussion of local ordinances does not consistently use the term erosion but refers to sensitive areas, critical areas, steep slope areas, etc.

2.6.4.2 Critique

The Application does not conform to local ordinances with respect to erosion hazards. Local ordinances are useful because they provide local criteria for identifying erosion hazards. The Application (p. 2.10-1) relies on a proposed Stormwater Pollution and Prevention Plan (SWPP) that is intended to meet NPDES and State Waste Discharge Baseline General Permit for Stormwater Discharges. As shown below, the Application does not clearly demonstrate the proposed SWPP Plan will meet all local ordinances that deal with erosion hazards.

King County: The Application (p. 1.6-14) states ATo construct a project within a sensitive area, an exemption process has been established to ensure compliance with the ordinance@ and Ato the extent feasible, the King County development standards are incorporated into pipeline design features.@ The language in the first sentence and term Ato the extent feasible@ conveys a high level of uncertainty that the proposed project will meet the requirements of Title 21A of the King County Zoning Code.

Snohomish County: Section 32.10.410 of the Snohomish County Code provides requirements for development in Aerosion hazard areas@. These include protecting erosion hazard areas by use of BMPs found in the Snohomish County Drainage Manual, or, using other erosion control measures if the applicant submits a geotechnical report demonstrating the alternative method will provide equal or greater protection. The Application (p. 1.6-17) states AOPL has determined the proposed pipeline and pump station is in conformance with existing zoning regulation.@ However, the Application does not identify the locations of erosion hazard areas as defined in this ordinance or explain how the proposed BMPs will meet the requirements of the Snohomish County Drainage Manual.

Grant and Adams Counties: The Grant County Resource Lands and Critical Areas Ordinance defines an Erosion Hazard as areas Aidentified as having high or very high water erosion hazard by the U.S. Department of Agriculture Soil Conservation Service as supplied by the Soil Conservation Service area office@. Site analysis is Arequired to determine exact location and circumstances that might be expected to precipitate a significant erosion event.@ The Adams County Code defines Erosion Hazard as Aareas that, at a minimum, include areas identified by the United States Department of Agriculture Soil Conservation Service as having a >severe= rill and inter-rill erosion hazard.@ The code requires an assessment of Athe potential for impact the project may have on the geologic hazard(s)@ and Athe potential for impact the geologic hazard(s) may have on the project.@

The Application (pp. 1.6-21 and 22) states ABased on available data, OPL has identified potential critical areas in this Application. OPL will coordinate with the Grant County Planning Department to further define critical areas, as appropriate@ and AOPL has identified potential critical areas in the pipeline corridor. OPL will coordinate with EFSEC and Adams County to further define potential critical areas and, as appropriate, determine what, if any, management policies may be applicable to mitigate potential impacts.@

Since erosion hazard areas were identified using Dept. of Agriculture soil surveys, the areas identified in the Application should be consistent with these county ordinances. However, as explained below, the method used in the Application to identify erosion hazards is ambiguous and may not have been properly applied. In addition, site-specific information on what Amight precipitate a significant erosion event@ is not discussed in the Application.

Publications are available that provide screening criteria for identifying erosion hazards. For example, the Stormwater Management Manual (Washington State Department of Ecology 1992, p. II-2-4) identifies areas that require Aspecial care@. These include slopes greater than 7% grade. The Manual also considers slope lengths greater than 75-ft with grades over 15% Apotential hazards@. The Manual notes that glacial till has low infiltration rates and Amay become saturated during large storms and produce significant amounts of surface runoff@. The Application does not cite these criteria when identifying erosion hazard areas on the proposed route.

2.6.5 STEP 4, IDENTIFY EROSION HAZARD AREAS

2.6.5.1 Application Presentation

The Application (pp. 2.10-3 to 4, 3.1-19 to 20) discusses some key factors regarding weathering and soil erosion processes. In general, the Application indicates that steep slopes (especially at stream crossings) are easily eroded if disturbed and, in eastern Washington, the aeolian-derived soils are subject to wind erosion when disturbed. Also easily eroded are the Asidewalls of streams@. For example, the Application (p. 3.1-19) notes that Aerosion-susceptible soils are present for portions of the proposed alignment, but are most commonly found on relatively seep slopes within drainages.@ Also mentioned is the importance of vegetation, soil cohesion and slope angle.

2.6.5.2 Critique

The method used to identify erosion hazard areas is unclear. One of the documents referenced in the Application is the Soil Survey of King County (U.S. Dept. of Agriculture 1973). According to this soil survey, erosion hazards are Arated according to the risk of erosion in woodland@. There are four levels of Ahazard@: slight (no special problem); moderate (moderate loss of soil where runoff is not controlled and the vegetative cover is not adequate for protection); and, severe and very severe (if steep slopes, rapid or very rapid runoff, and past erosion make the soil highly susceptible to erosion, and intensive management, including special equipment and methods that minimize soil deterioration are needed).

Soil erosion potentials on the STEH maps (Appendix B) show two categories of Aerosion potential@: moderate (shaded gray) and high (shaded black). Apparently, low erosion potential is unshaded, although this isn=t explained. On the other hand, the Application (pp. 3.1-33 and 34) discusses Aslight@, Alow@, Amoderate@, Ahigh@, Asevere erosion potentials@, Amoderately water erodible@ and high Awind erodibility@. The legend to the STEH maps, and the text, do not explain what the various erosion potential terms used in the Application mean or how all the U.S. Department of Agriculture (USDA) soil surveys were used to develop Aerosion potentials@.

Another shortcoming of the Application=s method for identifying erosion hazards is its failure to discuss the limitations of the applicability of the USDA erosion hazards to the proposed project. For example, the erosion hazards provided in the King County soil survey only evaluate erosion in woodland areas subject to removal of vegetation. The hazard ratings were not developed for active construction sites. Since construction will require removing vegetation, trenching the soil surface, stockpiling soil, and driving vehicles over the soil surface, more runoff and erosion could occur compared to a soil without adequate vegetative cover. Considering the intense construction activity along the corridor, and the limitations of the USDA soil surveys, the Aerosion potential= of the soils along the proposed corridor is probably greater than the STEH maps indicate.

2.6.6 STEP 5, IDENTIFY DATA NEEDS AND OBTAIN SITE-SPECIFIC DATA

2.6.6.1 Application Presentation

The Application states (pp. 2.10-1 and -5) ABMPs for each site depend on the physical characteristics of each site and will be determined during field observational and geotechnical surveys prior to construction.@

2.6.6.2 Critique

The Application does not present sufficient data for an assessment of Erosion and Sediment Impacts. Site-specific data are needed to assess the potential erosion impacts from the project. These include soil; topography; vegetation; groundwater table; neighboring water bodies; adjacent properties; drainage patterns; erosion hazard areas; existing developments and other sediment sources, utilities and contaminants. Existing contamination is likely to be a problem where the pipeline route follows a railroad right-of-way. In addition, construction related information will be needed, such as planned topographic changes; clearing and grading limits; drainage changes; materials to be used and storage locations; and access points for public roads.

2.6.7 STEP 6, DEVELOP APPROPRIATE DESIGN, CONSTRUCTION AND MITIGATION METHODS

2.6.7.1 Application Presentation

The Application states (p. 2.10-1) that a Stormwater Pollution Prevention Plan (SWPP) will be developed for construction and submitted at least 60-days prior to beginning construction. The SWPP Plan will have an Erosion and Sediment Control Plan (ESC) as one of its two parts (p. 2.10-1). The ESC will discuss BMPs. ABMPs for each site depend on the physical characteristics of each site and will be determined during field observational and geotechnical surveys prior to construction@ (Application, p. 2.10-1 and -5).

The Application also states (pp. 2.10-2 and -5) Awhere applicable, BMPs will be determined following the Department of Ecology=s Stormwater Management Manual for the Puget Sound Basin@ and AErosion and sediment control BMPs from the Stormwater Management Manual for the Puget Sound Basin (SWMM), (Ecology 1992), will be implemented wherever possible for the construction of the pipeline.@

Finally, the Application discusses specific BMPs and other mitigation measures primarily in Sections 1.4 (Mitigation Measures) and 2.10 (Surface-Water Runoff and Erosion Control).

2.6.7.2 Critique

Applicant=s use of the Stormwater Manual for the Puget Sound Basin has limited applicability to this project. Shortcomings with the Stormwater Management Manual and in the way the Applicant plans to implement the manual=s requirements limit its applicability to the proposed project.

Ecology recognizes that improvements in the manual are necessary and convened a technical advisory committee in January 1999 to begin revising Chapter 2 of the Manual (i.e., Erosion and Sediment Control). The Application does not discuss the inadequacies of the Stormwater Manual or whether pending revisions will affect BMPs or other requirements.

The Stormwater Manual was not designed to address problems east of the Cascade divide. Yet approximately 75% of the project activity would occur east of the divide. The proposed revisions to the Stormwater Manual may include erosion and sedimentation issues specific to the east side.

The Application does not clearly describe what the proposed Erosion and Sediment Control Plan (ESC) would consist of and what requirements it would meet. The ESC (a part of the proposed Stormwater Prevention and Pollution Plan) would be prepared after the project is approved and may describe site-specific BMPs that would be determined during design, Awhere applicable@. The ESC apparently would use BMPs from the Stormwater Management Manual, Aif possible@. The reviewer is left with a high level of uncertainty regarding the specific BMPs and mitigation measures discussed in the Application.

Ecology=s Stormwater Management Manual describes a process that is intended to reduce impacts from erosion and sedimentation. The process described is one of preparing and implementing a AStormwater Site Plan@. Presumably, this is analogous to the Applicant=s proposed ESC. Each Stormwater Site Plan must meet all the AMinimum Requirements@ described in Chapter I-2 of the Stormwater Management Manual. These requirements are, in turn, satisfied by the application of BMPs (Ecology 1992, p. I-01-8). According to the AFlowchart Demonstrating Minimum Requirements@ (Figure I-2-1), AMinimum Requirements 1 - 11 apply@ to the proposed pipeline project. Minimum Requirements 1 through 11 are described on pages I-2-6 through 15. For example, Minimum Requirement #1 says that, from October 1 to April 30, no soils shall remain unstabilized for more than 2 days. However, according to the Application, Aright-of-way clearing will be restricted to no more than three days worth of the average construction progressY@ and Aunfinished right-of-way reclamation will be restricted to one weeks= worth of progress (Application p. 1.4-1). The pipeline project should not be approved unless an ESC is prepared that meets all requirements of the most recent version of the Stormwater Management Manual, with additional requirements for sensitive areas and areas not adequately addressed in the manual (such as the east side).

The Erosion and Sediment Control Plan (ESC) should specify the procedures and methods selected for erosion, sediment and other pollutant controls and where, when, and how they will be applied. In addition, the plan should include calculations and reasoning, as well as inspection and maintenance provisions. The Application, on the other hand, identifies areas of erosion potential and discusses potential BMPs, but does not connect the two.

2.6.8 STEP 7, EVALUATE THE POTENTIAL IMPACTS CAUSED BY EROSION AND SEDIMENTATION

2.6.8.1 Application Presentation

The Application notes that erosion and sedimentation may impact wetlands (p. 3.4-22), fisheries

(2.10-7, 3.4-75 to 113) and riparian habitat (2.10-7). The Application does not discuss methods for estimating erosion rates except for a method (p. 3.4-112) of estimating the amount of sediment released by disturbing the streambed. The Application does not discuss sediment production in the basins of interest or the amount sediment that would be produced from the proposed project.

2.6.8.2 Critique

<u>The evaluation of stream crossing sensitivities and impacts is flawed.</u> The Application (p. 3.4-111) examines the stream crossing methods and evaluates Aimpact potential of crossings@. The Application divides crossings into two types Ainvasive@ and Anon-invasive@. The non-invasive methods are then not evaluated because they supposedly do not disturb the streambed (see Application p. 3.4-75). This analysis is flawed because Aunder-culvert@ and Aover-culvert@ crossings are included in the non-invasive group (with bridge crossings). Activities at under-culvert crossings will disturb the stream bed because the culvert has to be removed and the bed trenched in order to construct the pipeline. Stream beds at over-culvert crossings will also be disturbed at those locations where the culverts need replacement (Application p. 1.4-30). Many of the crossings listed on Table 3.4-8 are over- or under-culvert crossings.

The Application (p. 3.4-100) states that construction will not increase bedload and that Asuspended particles will be less than 100 micrometers in size and should, for the most part, be kept in suspension and not deposited in spawning gravels@. This is an oversimplification. The size distribution of the particles delivered to streams will reflect the size distribution of the erosion source(s), the transport processes and the effectiveness of BMPs. At locations where alluvial bank materials are disturbed (especially steep banks), some coarse sediment will almost certainly be added to the stream bedload. Steep approaches to streams are more likely to contribute coarser particles because runoff velocities are likely to be greater. This may occur during construction, operation and decommissioning.

Although the suspended load will be kept in suspension where water is turbulent, some of the suspended load will be deposited in pools. Also, suspended load can be filtered from the water as it flows through the stream bed (i.e., hyporheic flow). Suspended particles deposited in the streambed in this manner reduce the hydraulic conductivity and porosity of the stream bed. As a result, salmon eggs may be exposed to decreased oxygen concentrations, and emerging fry can be trapped in the stream bed (Koski, K.V. 1966; Meehan, W.R. and D.N. Swantson 1977; and Everest and others 1987).

The Application states that sediment deposited in stream channels as a result of construction will be flushed out in two years (p. 3.4-102). However, the amount of time it takes for the fine sediment from pipeline construction to flush out of the streams is dependent on storm events, sediment inputs from outer sources, and local conditions. Sediment transport capacity could be reduced if there is a sustained period with fewer major storm events. On the other hand, some of the streams may be receiving significant amounts of sediments from other sources (natural and anthropogenic) such that additional inputs from the pipeline exceed the stream=s ability to transport sediment. The

Application does not clearly show that both suspended load and bedload will not be significantly increased by construction activities and that significant amounts of the suspended load will not be deposited in the stream bed. In addition, the Application generally doesn=t differentiate between the tributary streams the pipeline crosses and the mainstems many of these tributaries join. Therefore, while it may be possible that a tributary stream isn=t affected by the project, the mainstem (which may have a lower gradient) could be.

The Application fails to address the impact of future repairs and maintenance of the pipeline. The Application assumes that all erosion will occur during construction (see pp. 2.10-25 to 27). However, repairs and maintenance will be needed and much of this work could occur near wetlands or water bodies where impacts would be greatest. As stated, the longer the pipeline is in use, the more it will have to be excavated and repaired and the more likely it will be to encounter contaminated soil. Furthermore, pipeline repairs may have to be done at locations and times that make it difficult to prevent erosion, contain runoff, and avoid fish impacts. Erosion of soil (including potentially contaminated soil) is likely to occur during these activities and there is the potential for environmental impacts associated with operation activities to be more significant than those associated with construction.

The high number of channel crossings in some basins warrants an evaluation of cumulative impacts. The proposed pipeline project will contribute sediment to basins that already have existing sources of sediment. If these basins already have or are predicted to have significant sediment impacts without the pipeline, then the additional sediment due to the proposed project is of special concern. Erosion-derived sediment can have cumulative impacts on fisheries, water quality and channel form (including bank erosion).

Sediment from construction activities at stream crossings should be evaluated. According to the Application (p.1.4-1), BMPs designed to reduce erosion and sedimentation may not be implemented for 3-days during right-of-way clearing, 2-days during trenching, and 7-days during reclamation. Stream crossing construction activities are also predicted to last up to 2-days (p. 3.4-51). Thus, up to 12-days of unmitigated erosion can occur at any or all crossings. Each crossing will have two 60-ft wide construction corridors leading down to the stream and one 30-ft wide stream crossing construction corridor. Furthermore, construction could occur during wet weather (p.1.4-11). The Application should provide an assessment of the amount of sediment inputs and its potential impacts. This is very important because construction would occur as early as June and end in the fall or early winter, include periods of low stream flow. Consequently sediment that enters the stream during construction is likely to be present while spawning occurs.

Methods for evaluating erosion and sediment production are available that were not cited in the Application. The Universal Soil Loss Equation (USLE) can be used to estimate the effects of sheet and rill erosion. Recent adaptations of several of the equation=s factors to construction site conditions allow use of the USLE to evaluate the effects of erosion control practices on building sites (Association of Bay Area Governments 1995, p. 5.1). Other publications are available that provide ways to estimate road erosion rates that may be applicable to aspects of the project (e.g., Washington

Forest Practices Board 1995). Methods for estimating sediment input and transport rates in the basins of interest are also available. Reid and Dunne (1996) and Paulson (1997) provide information on many methods commonly used.

A quantitative method should be used to evaluate project impacts. One method is to compare inputs from the proposed project to existing and likely future sediment production. If the conditions of resources and public/private works are known, impacts from the proposed project could be evaluated in a more objective manner. In basins that have been extensively studied, such as the Snoqualmie basin, it may be possible to use this method without collecting much more data. According to Reid and Dunne (1996), these evaluations can be accomplished within reasonable costs and time frames and without performing extensive field studies. The Application does not quantitatively evaluate the impacts of the proposed project.

2.6.9 STEP 8, PERFORM MONITORING AND MAINTENANCE

2.6.9.1 Application Presentation

Some of the monitoring discussed in the Application should detect erosion that occurs during operation. Aerial visual monitoring (p. 1.4-10) should be able to detect larger areas of erosion but it is doubtful whether the pilot would be able to see incipient erosion. There are 5-year monitoring plans for upland vegetation, for revegetation (pp. 1.4-20, 2.10-27) and for post construction mitigation of habitat (p. 3.4-56). These plans do not appear to be designed to monitor erosion and sedimentation impacts associated with operation.

2.6.9.2 Critique

BMPs should be inspected and maintained- Ecology=s Stormwater Management Manual (p. II-2-1) states the importance of inspecting and maintaining BMPs. Regular BMP inspection, especially during and after major storms should be required for this project.

Erosion should be monitored. Monitoring would provide an understanding of whether BMPs are effectively being implemented during construction and would supply data for understanding cumulative impacts. During operation, monitoring should be done periodically and after major storm events so areas of incipient erosion can be detected and stabilized as quickly as possible. Annual stereo aerial photographic coverage should be performed to document conditions along the route and evaluating erosion, vegetation and changes in land use.

2.6.10 SUMMARY AND CONCLUSIONS

The evaluation of erosion hazards presented in the Application is inadequate to determine the impact of the proposed project on erosion and sedimentation. This is very important because of the impact of sediment on fill and fish habitat. Erosion associated with pipeline operation and decommissioning is ignored. Erosion associated with construction is discussed, but there is no quantitative assessment of impact to the environment. Furthermore, there is little consideration of how erosion could lead to damage to the pipeline.

In all likelihood, this poor foundation led to the Application=s failure to review appropriate regional references and useful methods of analysis. This in turn led to the failure to address methods for design construction, mitigation, maintenance, and monitoring which are likely to protect the environment.

The Application does not convey a sense that appropriate information will be obtained and correctly applied prior to construction. The proposed project should not be approved until the deficiencies described are corrected.

2.7 CULVERT EVALUATION AND DESIGN

2.7.1 INTRODUCTION

Culverts are important because they can, and often do, function as controls on stream grade, stream flow, sediment and woody debris passage, and fish passage. Improper culvert design and maintenance can lead to sediment deposition upstream of the culvert, steam incision downstream of the culvert, perched outlets, culvert blockage by debris and riprap, road washouts and landslides. Even properly functioning culverts cause adverse environmental impacts by removing habitat and impeding fish passage.

The proposed project will cross many steams where proper culvert design and maintenance will be important for pipeline safety and habitat quality. The following steps should be accomplished to properly evaluate and design culverts along the proposed route:

Step 1: Conduct a survey of existing culverts.

Step 2: Identify information needed for proper culvert design.

Step 3: Design new and replacement culverts.

Step 4: Monitor and maintain culverts.

In the following sections, the Application treatment of culverts is evaluated following these steps.

2.7.2 STEP 1, CONDUCT A SURVEY OF EXISTING CULVERTS

2.7.2.1 Application Presentation

The Application (Table 3.4-8) presents a summary of stream crossing methods and fish usage. This table indicates where under- and over-culvert crossings are planned.

2.7.2.2 Critique

Sufficient data on existing culverts apparently was not collected. A proper culvert analysis requires collecting data including data on existing and anticipated flow approach conditions, culvert internal conditions, downstream conditions, and design flows (Johnson and Orsborn 1997). The DEIS (p. 3-143) recommends meeting with all landowners and entities with easements to ensure that all undersized culverts are identified. The Application does not indicate these data has been or will be collected to evaluate existing culverts.

Impacts from upstream culverts are not recognized in the Application. Failure of an upstream culvert can be just as devastating as the failure of a culvert at a pipeline-stream crossing. If a culvert upstream of a pipeline-stream crossing becomes blocked, a flood or debris flow may be initiated that will propagate down the stream channel. The resulting scour could damage or rupture the pipeline. A blocked upstream culvert could also divert water from the channel onto nearby road surfaces. The water could then flow down the road surface and cause erosion or landslides to occur at locations outside the stream channel and possibly where the pipeline is located. In order to reduce these hazards, upstream culverts must be evaluated, and in some locations, replaced or modified. These modifications should be consistent with salmon recovery efforts and with proper design features discussed subsequently.

The need for new culverts is not addressed. Pipeline inspection and maintenance will create traffic at stream crossings where culverts currently do not exist. Crossing these streams poses a dilemma: should culverts be placed in the steams? Placing a culvert in the stream will prevent erosion of the stream bank and stream bed and prevent vehicles from getting stuck. On the other hand, the culvert will eliminate stream habitat, reduce stream complexity, inhibit or block the passage of fish (especially weak-swimming fish) and create a future risk of culvert failure. Other methods of crossing streams, such as fords, also present problems. Methods for crossing streams are a good example of how mitigations transfer risk but do not eliminate it. The extent to which new culverts will impede fish passage needs to be addressed.

The Application does not identify existing culvert problems. It is important to have an understanding of existing culvert problems, such as existing or past culvert blockage, before beginning design on new or replacement culverts. For example, how significant is fish passage in limiting fish production in the basins of concern? As an example, the DEIS (p. 3-172) states available spawning and rearing habitat for bull trout could be increased at Mill and Cold Creeks if culverts are replaced.

2.7.3 STEP 2, IDENTIFY INFORMATION NEEDED FOR PROPER CULVERT DESIGN

The Application does not identify existing regulations that apply to culvert design, construction and maintenance. The Application (p. 1.6-13) identifies Title 75 RCW as requiring a Hydraulic Project Approval. However, the Application does not specifically state this applies to fish passage and culverts. Section 75.020.060 states AA dam or other obstruction across or in a stream shall be provided with a durable and efficient fishway approved by the director. Plans and specifications shall be provided to the department prior to the director=s approval.@ The Washington Administrative Code Chapter 220-110, which was established pursuant to 75.20 RCW, specifies fish passage design criteria for culverts (WAC 220-110-070). The Application does not discuss whether existing culverts meet regulatory criteria.

2.7.4 STEP 3, DESIGN NEW AND REPLACEMENT CULVERTS

2.7.4.1 Application Presentation

The Application (pp. 1.4-29; 2.14-10; Table 3.4-8) does not discuss culvert design, except to state @undersized culverts could be blocked by debris flows during winter storms, causing extensive erosionYUndersized culverts that are identified will be replaced as a pipeline mitigation measure. Where pre-existing blockages to migration of existing fish populations occurs, modifications to the culverts may be made as a mitigation measure.@

2.7.4.2 Critique

Culvert design criteria are available that are not discussed in the Application. Due to current efforts to improve fish stocks through habitat enhancement, there is sufficient information available on methods for selecting culverts for replacement and criteria for designing new culverts (e.g., Powers and Orsborn 1985; Behlke and others 1991; Johnson and others 1997; Johnson and Orsborn 1997; Washington State Department of Ecology 1992; WAC 220-110). The Application does not suggest any methods or criteria for culvert design.

The Application is inconsistent with Washington State=s efforts to protect and restore salmon resources. The design of many older culverts will probably not be consistent with current recommended practice. The Applicant=s (p. 1.4-29) statement Awhere preexisting blockages to migration of existing fish populations occurs, modifications to culverts may be made@ indicates culvert design will probably not adequately protect fish resources. In consideration of the current efforts to rebuild salmon stocks, the project should not be approved unless culverts are built to ensure passage of fish, sediment and woody debris consistent with salmon recovery and habitat restoration efforts (see Washington State Office of the Governor 1998, TFW, p.5)

Culvert design depends on the life of the project. Culvert design will depend, in part, on the life of the project, which the Application describes as Aindefinite@, and on whether culverts and the pipeline will be removed from stream crossings after pipeline use is terminated. A culvert sized for a 50-year flood has a 33% probability of failure during a 20-year design life (Furniss and others 1991). Culvert design must also consider culvert life. Culvert life should be as long as or longer than the proposed project. If culvert life is shorter than the proposed project, then the impacts to aquatic resources from replacing culverts should be evaluated. Both the design life of the project and the design storm event should be specified in order to adequately evaluate risk.

2.7.5 STEP 4, MONITOR AND MAINTAIN CULVERTS

2.7.5.1 Application Presentation

The Application does not discuss culvert monitoring and maintenance.

2.7.5.2 Critique

The Application does not indicate responsibility for culverts after the pipeline is built. The Application should address who will own and be responsible for monitoring and maintaining culverts and eventual removal of culverts. This should include those culverts upstream of the pipeline and culverts constructed after the pipeline is installed. The responsibility for pipeline and environmental impacts caused by failure of any culvert should also be established as well as for culvert removal after the project ends.

The Application should develop the monitoring schedule. The DEIS (p. 3-143) recommends monitoring culverts and channels 1 and 3 years after construction for desired fish passage and erosion concerns, taking the necessary corrective actions based on monitoring results, and adding any new structures to a long-term monitoring plan. Waiting one year before monitoring culverts could be risky. Culverts along the route and upstream of the pipeline should be monitored during the first year following all major storm events. In subsequent years, the frequency should depend upon observations made during the first year. Detailed culvert monitoring and inspection should take place no less than once per year during the entire life of the project.

2.8 EARTHQUAKES/SEISMICITY

2.8.1 INTRODUCTION

The present day seismicity of Washington State is related to its position on the Pacific Aring of fire.@ Active subduction along the western margin of the North American Plate produces large stresses in the earth=s crust that, in part, are relieved by earthquakes.

Past occurrences of very powerful earthquakes in the Pacific Northwest went unrecognized by earth scientists until the mid-1980=s. As a result of the discovery that great earthquakes occurred in the past and that seismic risks were greater than previously understood, the Uniform Building Code was revised in 1994. Before 1994, the code placed the Puget Sound area of Washington in the second highest of six levels of earthquake shaking hazard zones. The 1994 edition of the Uniform Building Code extended the higher level zone to include all parts of Oregon and Washington (Atwater and others, 1995). Current research suggests the seismic hazards may be greater still (Stricherz, 1999).

In light of our current understanding, it is especially troublesome that the Application evaluation of the seismic hazards along the proposed route is inadequate. A comprehensive evaluation of seismic hazards includes the following steps:

Step 1: Review literature and interview geologists and seismologists to identify known or suspected faults or other evidence of seismic activity

Step 2: Conduct field investigation to identify geomorphic features that may be indicative of faults, especially Quaternary faults

Step 3: Specify key seismic evaluation parameters related to risk posed to or by the pipeline

Step 4: Design pipeline and appurtenant structures to accommodate seismic activity

Step 5: Assess the consequences of failure caused by earthquakes, including multiple failures of the pipeline.

The remainder of this section addresses each of these components separately.

2.8.2 STEP 1, REVIEW LITERATURE AND INTERVIEW GEOLOGISTS AND SEISMOLOGISTS TO IDENTIFY KNOWN OR SUSPECTED FAULTS OR OTHER EVIDENCE OF SEISMIC ACTIVITY

2.8.2.1 Application Presentation

The Application discusses seismic hazards in Section 2.15.2 (Earthquake Hazard) and Section 3.1.4 (Potential Seismic Activity). References are provided for sources of information on ground shaking hazards, Quaternary faults and other geologic structures, the tectonic setting, earthquake locations and earthquake magnitudes. The Application (Figures 2.15-1a to 1f; Table 2.15-1) presented six maps that identified all suspected or known Quaternary faults within a 30-mile area surrounding the proposed pipeline corridor. Based on information presented in these maps and Table 2.15-1, the Application (concludes that Athe proposed pipeline does not cross the known surface trace of faults known or inferred to have been active during the late Quaternary (approximately 700,000 years ago to the present). Inactive faults which are crossed by the proposed route are present in Tertiary or older rocks, are locally covered by Quaternary deposits and lack the tectonic geomorphology indicative of late Quaternary surface displacement.@

2.8.2.2 Critique

<u>Credible information is available that was not used.</u> Reports on seismic hazards along portions of the proposed pipeline are available that apparently were not reviewed. Recently available geologic maps and literature (U. S. Department of Energy, 1988; Tolan and Reidel, 1989; Woodward-Clyde, 1992; Schuster, 1994; Reidel and Fecht, 1994; Reidel and others, 1994) reveal that the proposed pipeline route crosses or approaches the surface trace of at least six known or suspected Quaternary-age faults or fault zones. Known or suspected Quaternary-age faults or fault zones are crossed or approached by the proposed pipeline route in the Snoqualmie Valley, Kittitas Valley, Bolyston Mountain, Ryegrass Summit, Columbia River crossing, and on the Saddle Mountains. The Quaternary-age faults are described below.

Rattlesnake Mountain- Rattlesnake Mountain is a prominent northwest trending bedrock ridge located west of the cities of Snoqualmie and North Bend. Evidence of faulting along the east side of the escarpment was documented by Walsh and Logan (1985). A subsequent study for the Snoqualmie Ridge Project (Associated Earth Sciences, 1987) identified a possible extension of the fault to the north. The roughly 10-mile long original postulated fault and the 4-mile extension are shown on the attached figure. The Seattle Water Department reviewed the Rattlesnake Mountain Fault as part of their seismic evaluation for the Cedar Falls Dam (Woodward Clyde, 1992). They concluded that the linear character of the eastern flank of Rattlesnake Mountain combined with the findings of Associated Earth Sciences and Walsh and Logan Aled to the conservative approach of considering the feature as a potentially active structure for the seismic hazard assessment.@ The postulated Rattlesnake Mountain Fault roughly parallels the proposed pipeline route and is approximately two miles from the pipeline at North Bend.

Kittitas Valley- In the Kittitas Valley area, the proposed pipeline route crosses two east-west trending faults that are shown on pages of the GTMWH Mpas. Waitt (1979, p. 15) states that the age of last movement on these faults (faults X, Y and Z in Figure 2) was inferred to be between 3.7 million and 13,000 years ago. More recent evaluation by Reidel and others (1994) indicate a Pleistocene age (1.6 million to 10,000 years ago) for the most recent movement on these faults. Although the surface traces of these faults are shown where the proposed route crosses them, they were not recognized as Quaternary faults in the Application. The failure to recognize and assess the potential risk that these faults pose to the pipeline is a significant oversight.

Boylston Mountain - Ryegrass Summit. The proposed pipeline route east out of the Kittitas Valley and crosses Boylston Mountain (northwest-trending fold segment of the Saddle Mountains) and Ryegrass Summit (north-south-trending Hog Ranch Anticline). Suspected Quaternary faults are associated with both of the these anticlinal ridges and the proposed pipeline route crosses several of these suspected Quaternary faults. These faults are not portrayed on the Geology, Topography, and Mass Wasting Hazards Maps (Appendix B).

A Quaternary, east-west-trending thrust fault associated with the Boylston Mountain Anticline is crossed by the proposed pipeline route in section 9, T17N, R20E. This Quaternary fault is not shown on Map Atlas page 54, although its location is depicted on several current geologic maps (Tolan and Reidel, 1989; Schuster, 1994). Work by Bentley and Powell (1987) indicates that this fault juxtaposes 16 million year old Columbia River basalt over probable Quaternary-age talus, making the age of last movement on this fault Quaternary-age.

Additional north-south- and northwest-trending faults of suspected or known Quaternary-age are found on the Hog Ranch Anticline in the Ryegrass Summit area (Bentley and Powell, 1987; Tolan and Reidel, 1989; Schuster, 1994). None of these faults are depicted on the Geology, Topography, and Mass Wasting Hazards Maps (Map Atlas pages 57-59, Appendix B), but the proposed pipeline route crosses at least one of these Quaternary faults (e.g., secs. 22 and 27, T17N, R21E). Work by Bentley and Powell (1987) indicates that a sag pond is associated with at least one of these faults, suggestive of very recent movement (less than 10,000 years ago). The failure to recognize and assess the potential risk that these faults poses to the pipeline is a significant oversight.

Wanapum/Sentinel Gap Fault - The course of the Columbia River between the Frenchman Hills and the Saddle Mountains follows the traces of several north- to northwest-trending cross faults that define fold segment boundaries for both the Frenchman Hills and Saddle Mountains anticlinal ridges (Tolan and Reidel, 1989; Reidel and Fecht, 1994; Geomatrix, 1990, 1996). Recent seismotectonic evaluation of this area by Geomatrix (1990, 1996) judged that faults associated with the main structural trend of the Frenchman Hills and Saddle Mountains are potential active and pose a credible threat of generating moderate to large magnitude (ML 5 to 7+) events. These cross faults (Wanapum and Sentinel Gap faults) are kinematically linked parts of the Frenchman Hills and Saddle Mountains fault systems. Consequently, there is also a high potential for activity (movement) on these cross faults. The failure to recognize and assess the potential risk that these faults poses to the pipeline is a significant oversight.

Saddle Mountains Fault - The route of the proposed pipeline crosses the anticlinal ridge of the Saddle Mountains (Geology, Topography, and Mass Wasting Hazards Maps, p. 82) at the Saddle Gap structural segment (Reidel, 1984; Reidel, 1988; Geomatrix, 1990). The authoritative geologic map of Reidel and Fecht (1994) shows that a thrust fault paralleling the trend of the structural segment is inferred to be present along the entire length of the Saddle Gap structural segment. A seismotectonic evaluation of the Saddle Mountains conducted by Geomatrix (1990, p. 22a, 36-37) found evidence that suggested that Saddle Gap structural segment has experienced Quaternary-age deformation (fault movement) and must be classified as a "potentially active" geologic structure capable of generating a maximum credible earthquake of M 7 (Geomatrix, 1990, p. 101).

Map Atlas page 82 shows a thrust fault terminating just inside the eastern boundary of the proposed pipeline corridor. This fault, referred to as the "Saddle Mountains fault" in the Application, is the same fault shown by Reidel and Fecht (1994) as extending to the east (beneath the proposed pipeline route) and identified by Geomatrix (1990, 1996) as part of the potentially active Saddle Gap segment of the Saddle Mountains. The Application seems to acknowledges this discrepancy between their interpretation and published literature by stating:

"The pipeline corridor has been located to avoid the portion of the Saddle Mountains fault with documented recentactivity. However, the pipeline alignment may cross the buried eastern extension of the Saddle Mountains fault which is inferred to be present beneath the anticline crossed by the route (see Appendix B, pages 80-82)." However, this acknowledgment fails to point out that the proposed pipeline route does more than just cross this Quaternary-age fault, it will actually parallel this fault, lying within several hundred yards of it, for approximately 5 miles (mileposts 183.3 to 188.5).

2.8.3 STEP 2, CONDUCT FIELD INVESTIGATION TO IDENTIFY GEOMORPHIC FEATURES THAT MAY BE INDICATIVE OF FAULTS, ESPECIALLY QUATERNARY FAULTS

2.8.3.1 Application Presentation

The Application does not reference any specific field investigations to identify Quaternary faults that were conducted for this project. With respect to one suspected fault (Saddle Mountain Fault), the Application states that Aduring trenching for construction of this portion of the pipeline, the trench will be inspected for evidence of the fault or deformed soils by a qualified geologist.@

2.8.3.2 Critique

<u>It isn=t clear that a geomorphic investigation was accomplished for this project</u>. The Application implies there may have been one, but no reports or data are referenced. Performing a fault investigation during construction does not acknowledge the specialized nature of this type of meticulous, time-consuming examination, which is basically incompatible with construction activities. The depth of the pipe trench is not likely to be sufficient to identify a fault and the rushed pace of construction and risk of injury from construction equipment make it difficult or impossible to carry out a careful investigation. Furthermore, it would be difficult or impossible to reroute the pipeline at this late stage and, of course, it would be impossible to factor the presence of this fault into the decision on whether or not the pipeline should have been constructed. A geomorphic investigation, including field studies, should be conducted in advance of the project approval.

2.8.4 STEP 3, SPECIFY KEY SEISMIC EVALUATION PARAMETERS RELATED TO THE RISK POSED TO OR BY THE PIPELINE

2.8.4.1 Application Presentation

The Application (p. 2.15-2) presents mapped contours of peak ground acceleration (PGA) to Aquantify the groundshaking hazard within the pipeline corridor.@ These and the locations of faults and folds located within 30 miles of the proposed route are shown on Figures 2.15-1a through 2.15-1f. The contours presented represent earthquake ground motions that have a A10% probability of being exceeded within a 50-year period. An earthquake that generates ground motions having a 10% probability of exceedence in 50-years is defined as a >Contingency Design Earthquake,= or CDE, by the ASCE Technical Council on Lifeline Earthquake Engineering. The PGA along the alignment ranges from 0.29 at the western terminal near Woodinville to 0.08 at the eastern terminal near Pasco.@

The source of the ground motion data was the USGS National Seismic Hazard Mapping Project. The USGS produced seismic maps at three probability-of-exceedence levels, 10%, 5% and 2%.

The Application (p. 7.3-2) states AThe life of the Cross Cascade Pipeline Project is assumed to be indefinite with proper equipment maintenance, periodic overhauls, and upgrades.@

2.8.4.2 Critique

The seismic evaluation is deficient. The development of key seismic evaluation parameters includes three parts. The first and most critical is the selection of the appropriate risk level. This is often expressed in terms of a certain probability of exceedence. The probability of exceedence for non-strategic structures is standardized. For ALifeline@ structures, such as pipelines, it is often a policy decision made by government officials. For the Cross Cascade Pipeline, it appears that OPL examined three probability levels: 10%, 5% and 2%. As noted in the DEIS (p. 3-18) AY a 10% chance of being exceeded in a 50-year period Y correlates roughly to a 500-year return period.@ Similarly, a 5% and a 2% chance of exceedence during 50 years would correlate with return periods of roughly 1000 years and 2500 years respectively. The longer the return period, the larger the design earthquake and the safer the structure.

It is not clear from either the Application or the DEIS why the selection of the design probability and the design return period were left to OPL. As previously noted, this is an important policy decision which presumably should be made by EFSEC or some other representative of the State. It is also not clear how a design return period could be selected without knowing the design life of the pipeline. An indefinite design life translates into a virtual certainty that the design earthquake will occur.

Once the design probability or design return period is established, the next step is to establish design earthquake ground motions. Where there are no known or likely faults near the structure a probabilistic approach such as that described in the Application is used. Where faults have been identified in proximity to the structure, as is now the case for the proposed pipeline, it is appropriate to take the third step and conduct a deterministic assessment of ground motions and then select the most protective results from both the probabilistic and deterministic methods.

As part of the assessment, the Application identifies strong ground motion (shaking) induced by earthquake events as posing an obvious potential risk to the proposed pipeline and associated facilities. The Application states that "Figures 2.15-1a through 2.15-1f identify the known and suspected faults within a thirty-mile area surrounding the proposed pipeline corridor. The figures also include the contours of peak ground acceleration (PGA) that were developed to quantify the ground shaking hazard within the pipeline corridor ... The source of the ground motion data was the USGS National Seismic Hazards Mapping Project or NSHMP, which produced maps of earthquake ground shaking hazard for the United States (USGS Open- File Report 96-532).

The methodology incorporated both seismic activity and geologic data in defining a national model of seismogenic sources. The maps have been the subject of extensive review and were incorporated into the 1997 NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings." However the earthquake ground shaking hazard maps in USGS Open-File Report 96-532 are general, regional-scale maps that do not provide an adequate basis for determining site-specific seismic hazards along the proposed pipeline corridor.

The most fundamental limitation with the USGS regional-scale data (USGS Open-File Report 96-532) with respect to the proposed pipeline is that it does not incorporate the location of all known or suspected Quaternary faults (seismogenic sources) that could potentially impact the proposed pipeline and associated facilities. This fundamental limitation is obvious upon inspection of the map (USGS Open-File Report 96-532, Fig. 24) showing faults used to generate the seismic hazard maps. For the Columbia Plateau region (Kittitas Valley to Pasco), only one of the Quaternary faults identified in the Application Table 2.15-1 (Wallula Fault Zone - located approximately 8 miles south of the Pasco terminus of the proposed pipeline) was used in the USGS assessment. Other known and suspected Quaternary faults (e.g., those listed in the above Quaternary fault section, Frenchman Hills west of the Columbia River, Boylston Mountain, Hog Ranch Anticline) crossed by the proposed route, or in close proximity to it, were not used in the USGS analysis. All of these Quaternary faults have been identified as significant, or potential significant, sources for future, moderate to large magnitude earthquakes in this region and have been included in seismic hazard evaluations conducted for the U.S. Department of Energy Hanford facilities, Washington Public Power Supply System's nuclear reactor sites, and U.S. Department of Interior Bureau of Reclamation dams (e.g., WPPSS, 1981; Geomatrix, 1988, 1990, 1996). The number and proximity of these faults to the proposed pipeline argue for a significantly greater risk of strong ground motion posing a potential hazard to the pipeline than is currently shown on the USGS map.

The Application is deficient with respect to the development of seismic evaluation parameters for three reasons: 1) a clear and transparent policy decision was not made with respect to risk; 2) all known or suspected Quaternary faults were not identified; and 3) the seismic evaluation parameters were not based on the more conservative of both a probabilistic and a deterministic evaluation.

2.8.5 STEP 4, DESIGN PIPELINE AND APPURTENANT STRUCTURES TO ACCOMMODATE SEISMIC ACTIVITY

2.8.5.1 Application Presentation

The overall design approach for the proposed pipeline entails (1) design of the proposed pipeline and associated facilities to resist and minimize impacts posed by earthquake ground shaking (Application p. 2.15-1 and 2) and (2) avoiding crossing Quaternary faults (potentially active or active faults) to prevent any potential hazards from direct fault rupture of the pipeline and associated facilities.

2.8.5.2 Critique

Design deficiencies must be addressed before project approval. The preceeding discussion has identified the need for an important policy decision on acceptable risk and the need for further evaluation of known and suspected faults. Subsequent to these tasks, deterministic and probabilistic analyses should be performed. Where the pipeline passes in close proximity to faults and geologic structures which could significantly amplify (or attenuate) ground motions, site-specific analyses should be conducted.

Design deficiencies identified in the DEIS should be addressed. Two important examples follow:

The fault rupture hazard is too high near the Saddle Mountains- The DEIS (p. 3-37) states that further evaluation is required along the Saddle Mountains to determine if mitigation measures are needed. These mitigation measures might include flexible couplings, use of reinforced pipe, and installation of block valves.

A structural analysis of the Beverly Railroad Bridge is needed if it is used for crossing the Columbia River- The DEIS (p. 3-38) states that a detailed structural and seismic stability analysis of the bridge will be necessary to determine if substantial rehabilitation is needed.

Seismic risks could easily be modified in the future, yet no provisions appear to be in place to require reevaluation and potential upgrade of the pipeline. The Application does not state that upgrades will be required in response to improved seismic risk evaluations. This is important because the proposed pipeline should be considered a lifeline structure. Failure of the pipeline due to an earthquake could cause interruptions in fuel supplies and devastating impacts to the environment. For these reasons, reevaluation of seismic risk and structural improvements to the pipeline are likely to be necessary as more is learned about seismic activity and pipeline performance. The Application does not comment on this issue. Revaluation should be conducted as significant new information is learned but should b no less frequent than every ten years. A seismic review panel should be established to conduct this evaluation.

2.8.6 STEP 5, ASSESS THE CONSEQUENCES OF FAILURE CAUSED BY EARTHQUAKE, INCLUDING MULTIPLE FAILURES OF THE PIPELINE

2.8.6.1 Application Presentation

The Application (Sections 2.15.2 and 3.1.4) discusses the potential that fault ruptures could sever the pipeline. The Application (p. 2.15-1) states Apossible impacts to pump station and terminal facilities from fault rupture and liquefaction include shearing of foundation and wall junctures, support cracking or shearing, loss of bearing pressure, and roof collapse.@

2.8.6.2 Critique

There is no requirement to shut down the pipeline and check for leaks if an unusual seismic event occurs. If the pipeline were to rupture during a large earthquake, the Application explains that a pressure drop will occur and the pipeline will shut down. However, the Application does not address the procedure to be performed following smaller earthquakes that do not result in apparent damage. Since these earthquakes may cause small leaks, it is important that such a procedure be developed.

The Application does not adequately address the earthquake-induced landslide hazard. Seismic shaking is likely to trigger landslides. Slope stability analyses discussed in Section 4.0 should incorporate appropriate seismic parameters.

The Application does not address the consequence of a pipeline failure caused by an earthquake. An earthquake is likely to cause multiple kinds of failures and failures at multiple locations. For example, an earthquake, especially a large one, may cause landslides, liquefaction and other structural failures. These failures may occur at more than one location. In addition, infrastructure such as roads, bridges, communication lines, and power lines, may be damaged. Multiple failures and infrastructure damage will reduce the ability of response crews to effectively respond to a major earthquake. Neither the Application text nor spill scenarios in Appendix B evaluate the consequences of earthquake-induced damage. This is an important concern that should be addressed in a revised application.

2.8.7 SUMMARY AND CONCLUSIONS

Until a technically defensible seismic evaluation is conducted, the potential hazards to the proposed pipeline and associated facilities may not be credibly defined. The current designs for the pipeline and associated facilities may not be adequate to withstand the effects from earthquakes. An appropriate risk level and design life for the proposed project will also have to be defined so that proper probabilistic analyses for pipeline failure due to seismic events can be undertaken. It is not possible to identify the potential environmental impacts associated with the pipeline and facilities until the hazards from earthquakes are completely defined.

2.9 LIQUIFACTION

2.9.1 INTRODUCTION

Liquefaction refers to a strength reduction in soil caused by the build up of water pressure. Liquefaction is most often associated with earthquake vibrations and their influence on saturated loose granular soil. Since the Niigata, Japan and Anchorage, Alaska earthquakes of 1964, where severe damage occurred due to liquefaction, there has been increasing interest in liquefaction. Although not as noteworthy as the seismic type, liquefaction can also occur under static conditions (Holtz and Kovacs, 1981). Liquefaction is also suspected to occur in moderately dense sand if the earthquake vibrations last long enough.

2.9.1.1 Application Presentation

The Application discusses liquefaction in Section 2.15 (Protection from Natural Hazards). The Application identifies earthquake-induced liquefaction as a potential hazard to the pipeline and identifies general geologic settings where the soil is prone to liquefaction. The Application presents an evaluation method and results for identifying liquefaction hazard areas along the proposed route. These results are summarized in Tables 2.15-2 and 2.15-3. Protective measures against liquefaction are also discussed in this section.

2.9.1.2 Critique

The DEIS identified two more liquefaction areas than the Application. The DEIS (pp. 3-19, 3-20) presents a table of liquefaction areas (DEIS Table 3.2-3) and notes they were taken from the Application Map Atlas. The DEIS Table 3.2-3 appears to be based on the Application Table 2.15-3 (Application p. 2.15-15) but with the addition of two liquefaction areas. These are the Tolt River and Cherry Creek crossings. These two liquefaction hazard areas do not appear on the Application Map Atlas figures and Application Table 2.15-3.

The potential for liquefaction is probably greater than that considered in the Application. The Application fails to address those additional circumstances where dense granular soil can liquefy during dynamic loading and where loose granular soil can liquefy during static loading. These possibilities merit consideration, especially in hilly terrain and in proximity to erosive water bodies.

The Application further states that the areas not susceptible to liquefaction include those where the groundwater is greater than 12 m (40 feet) below the ground surface. While this is correct, the lack of detailed surface topographic information and the probable presence of unidentified shallow water-bearing zones preclude an independent evaluation. Furthermore, groundwater levels, especially in irrigated areas, undergo both yearly and long term changes. This is not considered in the Application.

A concern with the liquefaction assessment presented in the Application is how areas along the proposed pipeline corridor were evaluated and ranked as to their liquefaction susceptibility. Table 2.15-2 in the Application (p. 2.15-13) presents the liquefaction susceptibility of geologic units (when saturated). Quaternary alluvium (map symbol "Qa") is ranked 5, on a scale of 1 (non-liquefiable) to 5 (liquefiable throughout), that is, highly susceptibility to liquefaction when saturated. After evaluating the screening level hazard areas, the Application states "Areas of low, moderate and high liquefaction susceptibility are shown on the geologic and hazard maps in Appendix B."

However, the GTMWH Maps (Appendix B) only show a few areas of "liquefaction potential" with no indication as to the level of potential hazard (i.e., low, moderate, or high liquefaction susceptibility) or the cause (seismic-induced or static). In addition, large areas of Quaternary alluvium along the Yakima River and in the Kittitas Valley, where ground water may be relatively shallow, should have been evaluated (based on criteria set forth in Table 2.15-2) but were not. This discrepancy between evaluation criteria and evaluation results is never explained, yet present throughout the rest of the GTMWH as well as Table 2.15-3.

A review of the GTMWH maps identified 9 additional areas of Quaternary alluvium (ranked A5@ in liquefaction susceptibility) that are crossed by the proposed pipeline route, from the Kittitas Valley to Pasco, but are not evaluated in the Application. These are:

Location (Mile Marker)	Stream Crossing No.
East of 96	147
East of	151/152
East of 103	157
East of 108	172
South of 111	180
West of 114 to 125	
South of 148	219/220
South of 149	223
East of 180	26e/26f

A concern also exists with the criteria apparently employed to make the evaluation presented in Table 2.15-3 for the Kittitas Valley to Pasco portion of the proposed pipeline corridor (east of pipeline mile marker 96). Twenty-seven (27) sites or "areas" that posed potential liquefaction hazards were inventoried and evaluated in the Application (Table 2.15-3). This evaluation was based upon two critical components - (1) site-specific geologic data and (2) site-specific, credible peak ground acceleration (PGA) values. As discussed above, peak ground acceleration values (PGA) derived from the USGS Open-File Report 96-532 and assumed earthquake magnitudes that are used in the Application (0.1g to 0.3g) are likely underestimated for the proposed pipeline route from the Kittitas Valley to Pasco. It is probable that maximum credible magnitudes and PGA values could exceed the design base of 0.3g along the Kittitas Valley to Pasco portion of the proposed pipeline because of its proximity to major seismogenic structures not addressed by the USGS assessment (e.g., see Geomatrix 1990, 1996).

Another concern with the liquefaction evaluation was that only 12 of the 27 sites were actually "field investigated" to determine site-specific geologic data. No site-specific data was collected for the other 15 sites; however, all but one of these non-investigated sites were given a ranking of "1" (non-liquefiable). The other was ranked A2@ (predominantly non-liquefiable). No basis or rational was presented for classifying these non-field investigated sites. The results for the 12 sites that underwent field investigation were not presented in the Application. Consequently, this information can not be independently evaluated.

The liquefaction susceptibility evaluation presented in the Application fails to develop seismic parameters and site-specific geologic data required for such a hazard analysis. Two apparently sequential methods for assessing liquefaction susceptibility are presented, but the rational and correlation between these methods and their assumptions are not explained. Furthermore, the evaluation criteria are not consistently applied.

2.9.2 SUMMARY AND CONCLUSIONS

The liquefaction susceptibility evaluation presented in the Application is inadequate. Work is required to develop technically defensible evaluation for seismic-induced liquefaction and should include the following.

Basic site-specific geologic data should be collected for all previously identified liquefaction susceptible areas and areas previously overlooked in the Application.

The risk to the pipeline as a result of liquefaction for all sites should be based on estimates of peak ground acceleration (PGA) from seismic evaluation described in the previous section.

3.0 HUMAN HEALTH RISK

3.1 INTRODUCTION

The toxicity of petroleum to humans and the potential threat a petroleum release presents to human health is implicit in the Application. For example, the Application examines spill scenarios and considers impacts to aquifers used for drinking water. However, the Application fails to consider all exposure pathways and the abundance of scientific information available to identify the level and extent of potential human health impacts if a release were to occur. Without consideration of the toxicity of petroleum and its additives, all potential human exposure pathways, and the magnitude of risk that the potential exposure represents, it is unlikely that a decision maker could make a reasoned examination of the potential impact of petroleum releases on human health.

The evaluation of human health risk from a potential pipeline release is an extremely important component of the overall evaluation of potential threat the pipeline poses to the communities along its route. If risk to human health is not examined, any evaluation of potential threat or risk posed by the pipeline will seriously underestimate the true risk. Furthermore, if potential human health risk is not evaluated, the knowledge gained from such an evaluation cannot be used in optimum design of the pipeline or in identifying appropriate mitigation measures.

In addition to contamination resulting from pipeline spills, other contaminants are likely to be encountered during construction of the pipeline. Contaminated soil is especially likely along abandoned railroad rights-of-way and close to underground storage tanks and commercial or industrial operations. It is important to check for indicators of potential contaminants using procedures similar to the Adue diligence@ investigations performed for property transactions. An important component of such a study is to check for known past chemical releases, including railroad accidents. It is not clear from the Application if such an investigation has been performed or if one is planned.

Given the likelihood of encountering contamination during construction, a plan should be put in place to protect workers and the public, notify appropriate regulatory agencies, and clean up the contaminated material. Steps should be taken to avoid placing the contaminated soil back in the excavation or removing it to a non-regulated disposal area. Obviously, it is also important to clearly identify whether it is the property owner or the pipeline company who has the responsibility for and bears the costs of these activities.

The process for evaluating human health risk from exposure to chemicals released in the environment has evolved very rapidly since the early 1980=s. Although there is still uncertainty associated with most risk assessments because of data gaps, federal and state regulators have developed generally accepted practices for evaluating human health risk from release of chemicals to the environment. These practices are based on technical research in the areas of chemical exposure and toxicity.

The potential risk to human health from a release of petroleum product from the proposed pipeline can be evaluated using well-established qualitative and quantitative techniques. The potential threat to human health posed by such a release is dependent on both the type and duration of the exposure sustained and the toxicity of the petroleum product. Such an evaluation would involve examination of Awhat-if@ scenarios appropriate to the different areas to be traversed by the proposed pipeline; for example, what if the pipeline were to release 10,000 gallons of gasoline over a 3-month period and resulted in a certain level of gasoline contamination in groundwater that is used as a source of potable water by a community? Another example might be, what if the pipeline were to release 5,000 gallons of diesel that migrated to the foundation of a school, resulting in a certain level of vapor intrusion into the building? In this type of prospective risk evaluation, a range of plausible scenarios are evaluated to examine the range of potential risks that may be sustained. This is in contrast to the Aretrospective@ risk assessment that is typically conducted for sites where a release has already occurred, and where conditions are known and relatively static.

This section discusses the state of the science and abundance of scientific information, tools, and guidance that are available in assessing exposure and toxicity that should be considered in evaluating human health risk associated with release of petroleum from the proposed pipeline. An evaluation of human health risk includes the following steps:

Step 1: Exposure assessment

Step 2: Toxicity assessment

Step 3: Risk characterization.

3.2 STEP 1, EXPOSURE ASSESSMENT

The exposure assessment identifies human receptor populations that could potentially come in contact with a petroleum release, describes these populations with respect to the type and level of exposure that could occur, and estimates the level of exposure that may be sustained by each identified receptor population through all applicable exposure pathways.

3.2.1 IDENTIFICATION OF RECEPTOR POPULATIONS

Potential receptor populations are identified through examination of current and potential future land use of the area. This information should be obtained through consultation with the local land use jurisdiction, and review of such information as zoning designations and any land use management or planning documents for the area. Any petroleum release from the pipeline represents a potential threat to ground and surface water. In many areas of the state, especially rural areas, ground and locally available surface water represents the only viable source of potable water. To address this potential threat to human health, a beneficial water use determination should be conducted to assess current use of ground and surface water in the area of potential impact, and future development that may affect this use. The Washington State Department of Ecology (Ecology) and the US Environmental Protection Agency (USEPA) have developed guidance documents that outline specific steps that should be followed in identifying current and future land and water use in the area potentially impacted by a petroleum release.

Risk assessment guidance developed by state and federal regulators identifies potentially important receptor populations such as residential and industrial populations to address common categories of potential land use. However, other types of land use may be very important to specific areas of the proposed pipeline course. These other types of land use may not be well represented by the more common designations, but may be critical in terms of defining potential upper-bound levels of exposure to the population. For example, land use by persons practicing sustenance farming may result in a much higher level of exposure than the level of exposure defined by residential or industrial land use. Land and water use by Native Americans may result in types and levels of exposures not anticipated in generally recognized land use categories. Native Americans may practice rituals that result in higher levels of exposure, or rely on food items such as fish for a higher proportion of their diet than other members of the population present. The presence of these sub-populations that may practice activities that will result in higher levels of exposure must be considered in identifying current and future land use to insure that all representative types of land use are included in risk evaluation.

3.2.2 IDENTIFICATION OF EXPOSURE PATHWAYS

A petroleum product release from the proposed pipeline could result in contamination of surface and subsurface soil, groundwater, and surface water. The petroleum product consists of some chemicals that will volatilize to the air, migrate through soil, and potentially bioaccumulate in animal and plant life. As such, the variety of exposure pathways available for contact is large. Some of these pathways will represent a higher level of potential exposure and risk than others, and contribution from each pathway will vary with location, spill characteristics, and identified receptor populations.

The only potential exposure pathway referenced in the Application is exposure through ingestion of water. This is inadequate and is likely to result in a significant underestimation of risk. For example, petroleum release to a ground or surface water source that is used as a source of potable water may also result in human contact through other exposure routes. Many petroleum compounds are lipid soluble and can pass through the skin when contact occurs. Use of petroleum-contaminated water as a potable water source may also cause release of the more volatile compounds from the water, resulting in inhalation exposure. Dermal contact with contaminated water and inhalation of volatile compounds could result in as much exposure as drinking the water.

Additionally, petroleum products released to soil may also present a potential health threat. Petroleum released to surface soil may result in exposure through incidental ingestion of the soil and through dermal contact with the soil. The petroleum product may also present a risk of exposure through the inhalation of volatile petroleum compounds. A petroleum release to subsurface soil may result in exposure via the same pathways if soil excavation is conducted in the area to support construction or utility work. A subsurface release may also result in inhalation exposure if product migrated to or under occupied structures where vapor migration to indoor air might occur.

Compounds present in petroleum products may also bioaccumulate in organisms once a product has been released to the environment. Petroleum products and their related compounds released to soil are known to bioaccumulate in plant and animal products that may be ingested by humans. Petroleum products and their related compounds released to surface water are known to bioaccumulate in fish and shellfish that may be ingested by humans.

In summary, the potential exposure pathways identified that should be examined for applicability and assessed in the DEIS and Application include:

Ingestion of contaminated soil and water

Dermal contact with contaminated soil and water

Inhalation of the volatile petroleum fraction from contaminated soil and water

Inhalation of fugitive dusts from contaminated soil

Ingestion of plants that have bioaccumulated contamination from soil

Ingestion of animal products that have bioaccumulated contamination from soil

Ingestion of fish or shellfish that have bioaccumulated contamination from contaminated water or sediment.

The relative importance of each of these potential exposure pathways depends on the petroleum product released. Petroleum products such as gasoline have a higher percentage of volatile compounds and will represent a risk from direct contact pathways, but also from the inhalation exposure pathways. Petroleum products such as diesel fuel have a lower volatile fraction, but a higher percentage of carcinogenic PAH compounds, which represent the greatest risk from direct contact pathways such as ingestion and dermal contact. Individual petroleum compounds vary greatly in their bioaccumulation potential, and the importance of pathways involving ingestion of plant or animal products that have bioaccumlated these compounds will depend on the product released and the circumstances of the release.

These exposure pathways have been characterized for the general population by state and federal regulators, and numerous guidance documents and references are available, such as the *Risk Assessment Guidance for Superfund* (EPA 1989 and supplements). These documents and references should be referenced to characterize all appropriate exposure pathways for the identified receptor populations. Each exposure pathway is then reduced to a mathematical equation that allows estimation of chemical intake (dose).

3.2.3 IDENTIFICATION OF EXPOSURE PARAMETERS

The mathematical equation used to estimate chemical intake through each exposure pathway is composed of exposure parameters. It represents the concept that the amount of contaminant that enters the body depends both on the concentration of that contaminant in the medium taken into the body (the exposure point concentration) and the conditions of exposure. An example of the basic intake equation used in calculating chemical intake through an individual exposure route is:

Where:

ADD = average daily dose of the contaminant

C = concentration of the contaminant in the environmental medium

IR = intake/contact rate

CF = conversion factor

EF = exposure frequency

ED = exposure duration

BW = body weight

AT = averaging time

This is a generalized intake equation that would be modified as appropriate to estimate contaminant intake through each exposure route. Parameters used in these equations to define intake have been researched and compiled in various reference and guidance documents such as *EPA Risk Assessment Guidance for Superfund* (EPA 1989 and supplements), *EPA Exposure Factors Handbook* (EPA 1997), *Assessing Human Health Risks from Chemically Contaminated Fish and Shellfish* (EPA1989), and *Dermal Exposure Assessment: Principals and Applications* (EPA 1992). Although exposure factors may be relatively well-characterized for members of the general population, their applicability to members of sub-populations that may sustain much higher levels of contact must be considered. Sub-populations such as Native Americans and sustenance farmers may have levels of contact that require development of site-specific parameters that better characterize the exposures of these people.

Exposure parameters are generally defined as either central tendency parameters (a mean or average value for the parameter) or reasonable maximum exposure parameters (the highest value the parameter is reasonably expected to assume). We recommend that exposure be characterized for both exposure conditions to Abound@ the range of exposures that may occur as a result of a petroleum release. Again, exposures sustained by special sub-populations may be higher than the defined reasonable maximum exposure, and should be examined as appropriate on a site-specific basis.

3.3 STEP 2, TOXICITY ASSESSMENT

Petroleum products including gasoline, diesel, and other refined products consist of complex mixtures of hydrocarbon compounds. Some of the compounds in petroleum products are known or suspected human carcinogens while others can cause both chronic and acute systemic health effects. The toxicity of some of the compounds known to be present in petroleum products, such as benzene, ethyl benzene, toluene, and xylene (BETX) and a chemical group known as polynuclear aromatic hydrocarbons (PAHs) is relatively well characterized. Benzene is a known human carcinogen, and many of the high molecular weight PAHs are considered probable carcinogens. Noncarcinogenic health effects associated with exposure to ethyl benzene, toluene and xylene, and PAHs such as naphthalene and pyrene, are well documented. The toxicity of most of the compounds present in petroleum has not been clearly defined. However, methods have been developed for evaluating the toxicity of these other compounds.

In addition to the chemicals known to be naturally present in refined petroleum products, other chemicals are added to petroleum for various reasons. For example, oxygenated compounds such as alcohols (methanol, ethanol) and ethers (methyl tertiarybutyl ether or MTBE) are sometimes added to gasoline as octane boosters and to reduce carbon monoxide emissions. MTBE is categorized by EPA as a potential human carcinogen, and its potential contribution to risk should be examined when evaluating potential release of gasoline. The potential presence of other chemicals in the petroleum product must also be examined. Since the presence or absence of these additive compounds may vary from one product stream to the other, we suggest that the full range of additives and their potential concentrations be noted in the Application and included in the risk evaluation. A clearly defined procedure should also be developed to address the proposed changes to the product stream that would introduce new toxic constituents to the pipeline. Clearly the public has a right to know and understand the risks posed by a potential release.

3.3.1 TOXICITY-BASED STANDARDS

Regulatory standards exist for the better-characterized compounds in petroleum. Maximum contaminant levels (MCLs), which define safe levels in drinking water, are available for these compounds. Ambient water quality criteria, which define safe levels in surface water based on water and fish ingestion, are also available. Occupational exposure limits to protect workers have been established for these compounds and include Permissible Exposure Limits, which establish airborne concentrations for an 8-hour work day, and Ceiling Limits, which define maximum airborne concentrations allowed for short-term (15 minute) exposures. These toxicity-based standards are all potentially applicable to situations when a petroleum product is released to the environment, and should be considered in the Application.

3.3.2 TOXICITY CRITERIA USED IN EVALUATING HUMAN HEALTH RISK

Toxicity criteria have been developed for the better-characterized compounds in petroleum such as BETX, PAH compounds, and petroleum additives by the USEPA that relate the dose of the compound through various exposure routes to potential health effects. These toxicity criteria, which are referred to as potency factors for known or suspected carcinogens and reference dose factors or reference concentrations for noncarcinogens, allow risk estimates to be made based on presumed exposure. These toxicity criteria can be used with exposure estimates developed using methods described in Section 2.0 to estimate the risk associated with these compounds under the identified exposure conditions. The process of characterizing risk based on exposure estimates and the established toxicity criteria is outlined in many state and federal guidance documents and other references, including the *Risk Assessment Guidance for Superfund* (EPA 1989 and supplements). The current toxicity criteria that are approved for use by the USEPA are posted on the EPA Integrated Risk Information System (IRIS), which is available through the EPA web site, and through the current Health Effects Summary Tables, published by EPA.

The toxicity of most of the compounds in petroleum has not been clearly defined. However, a technique has been developed to evaluate the relationship between dose and toxic effect of these compounds using information available for a small subset of the compounds present in petroleum. This technique evaluates individual aliphatic and aromatic hydrocarbon fractions and assigns each fraction a Asurrogate@ toxicity value based on the known toxicity of one of the compounds present in the fraction. In other words, all compounds in the fraction are assumed to be equivalent in toxicity to the compound in the fraction selected as surrogate. The surrogate selection is done in a Aconservative@ manner to insure that the selected surrogate toxicity value will not underestimate the toxicity of other compounds in the fraction. This method allows the toxicity of the entire petroleum product to be evaluated, rather than the methods used in the past that focus only on the well characterized compounds in petroleum products. The approach has evolved from work completed by the National Total Petroleum Hydrocarbon (TPH) Criteria Working Group (TPHCWG), and is referenced in their document *Development of Fraction-Specific Reference Doses*

(RfDs) for Total Petroleum Hydrocarbon (TPH) (TPHCWG 1996). This approach has been rigorously peer reviewed and has been adopted by several states, including Massachusetts and Alaska, for evaluation of petroleum contamination. The state of Washington is currently considering incorporation of a surrogate approach based on this method in the revised Model Toxics Control Act Cleanup Regulations. This method should be considered for use in assigning toxicity to petroleum products that could be released from the proposed pipeline. An example of application of these methods is provided in Section 3.5.

3.4 STEP 3, RISK CHARACTERIZATION

As discussed in Section 1.0, the type of risk evaluation appropriate for examining human health risk from a petroleum release is the type of evaluation in which a range of potential scenarios and outcomes is identified. Once the magnitude of a potential spill is established, the concentrations of petroleum product in soil and groundwater at the location examined can be established. Using the estimated concentration of the petroleum product in the environmental media and the methods outlined in this section, an evaluation of potential risk can be conducted.

In presenting an example of the risk characterization process, we will assume that a quantity of gasoline was released from the proposed pipeline into subsurface soil. This release resulted in soil contamination as high as 10,000 mg/kg petroleum, and groundwater contamination as high as 5 mg/L petroleum. The concentration of benzene in gasoline ranges from 2% to 3% (*Implementation of VPH/EPH Approach*, Massachusetts Department of Environmental Protection 1996).. If a 3% benzene content of the gasoline product is assumed, the concentration of benzene in soil can be assumed to be 300 mg/kg. The gasoline product is assumed to be 50% aliphatic compounds and 50% aromatic compounds, based on default compositional assumptions for gasoline recommended in *Implementation of VPH/EPH Approach* (Massachusetts Department of Environmental Protection 1996). For simplicity of presentation, this example will be limited to evaluating the human health risk associated with benzene and the total petroleum hydrocarbon product.

Potential exposure pathways that may bring receptors in contact with the product include incidental ingestion, dermal contact, and inhalation of vapors from contaminated soil and groundwater. If we limit our evaluation of risk to only the incidental soil ingestion pathway, the presence of 10,000 mg/kg gasoline in soil presents an unacceptable risk. The excess cancer risk associated with 300 mg/kg benzene from incidental ingestion of soil in a residential setting calculates to be nine in one million, using the default formula and exposure parameters in the Washington Model Toxics Control Act Cleanup Regulations (MTCA). The limit on excess cancer risk for individual carcinogens under MTCA is 1 in one million. The noncarcinogenic hazard index associated with 9,700 mg/kg gasoline hydrocarbons in soil is 3.0, using the default formula and exposure parameters in MTCA. The limit on the acceptable hazard index is 1.0 under the regulations. Similar analyses can and should be performed for several spill scenarios along the pipeline route.

3.5 CONSIDERATION OF AESTHETIC FACTORS

The term Aaesthetic factors@ encompasses a wide variety of qualities, such as odor, taste, and appearance. Petroleum products contain many compounds with low odor and taste thresholds. As such, relatively small quantities of a petroleum product released to soil or water will be noticed through odor or taste while it may not actually represent a severe health threat. Although difficult to quantify and not typically included in risk evaluations, aesthetic properties can contribute to non-life threatening health effects such as nausea and headaches. The presence of odor or an unpleasant taste in water can also lead people to perceive that more significant health risks are present. It is important to identify whether or not cleanup activities (and the proposed compensation plan) will address aesthetic impacts even if the risk-based cleanup levels do not otherwise require cleanup to below levels of aesthetic concern.

4.0 AQUIFER IMPACTS

4.1 INTRODUCTION

The revised Application includes a review and evaluation of groundwater issues. This review and evaluation is presented in Section 3.3.5 (Groundwater Resources) of the Application. Additional information is included in other Sections of the Application including Section 3.3 (Water) in general, Section 2.9 (Spill Prevention and Control), and a Product Spill Analysis (May 24 1997) (Application Appendix B-2).

The groundwater resource evaluation should provide the basis for identifying potential aquifer impacts and appropriate mitigation. Unfortunately, the Application evaluation is incomplete and difficult to understand. Also, there is not a clear link between aquifer characteristics and proposed mitigation. The aquifer characterization should include the following steps:

Step 1: Characterize Aquifers in the Vicnity of the Pipeline Route

Step 2: Identify Regulatory Restrictions and Requirements

Step 3: Identify Aquifer Uses

Step 4: Develop a Sensitivity Rating Scheme Based Both on Aquifer Characteristics and Uses Consistent with Existing Regulations

Step 5: Identify Potential Construction Impacts to Aquifers and Use the Sensitivity Index to Develop Mitigation Measures

Step 6: Identify Potential Operation Impacts to Aquifers and Use the Sensitivity Index to Develop Mitigation Measures.

Each of these six steps is discussed below. This discussion includes a summary and critique of the Application presentation.

4.2 STEP 1: CHARACTERIZE AQUIFERS IN THE VICINITY OF THE PIPELINE ROUTE

The Application characterizes groundwater resources in terms of three technical classifications. These classifications are aquifer type, depth to water, and separation sediments.

4.2.1 AQUIFER TYPE

Groundwater conditions along the CCP route are classified in the Application into eight general aquifer types (p. 3.3-55). Seven of these types are based on geologic soil or rock type (i.e. alluvium, glacio-fluvial deposits, Cascade Mountain bedrock, loess/dune deposits, outburst flood deposits, lacustrine deposits, Columbia River basalt). An eighth type, sole-source aquifer, is based on a regulatory designation. The Application associates general characteristics, issues and concerns, and mitigation with each aquifer type. The Application later redefines aquifer types in terms of groundwater regimes (Table 3.3-10) or hydrogeologic regimes (Figure 3.3-6), which in turn is one of four parameters used to calculate a groundwater sensitivity/impact rating for specific segments along the pipeline. The location of aquifer types or hydrologic regimes is summarized along the route on Figure 3.3-6. The designation of aquifer type/hydrogeologic regime is important in the context of the Application because it provides both a qualitative and quantitative basis for determining groundwater impact sensitivity. This characterization is also used as a basis for product spill analyses presented in Appendix B-2 and as a framework for understanding the risk to groundwater users and the likely effectiveness of proposed mitigation measures.

4.2.2 DEPTH TO WATER

Groundwater resources are also characterized in the Application by depth to water. Shallower groundwater is more susceptible to impacts from a release of fuel. Also, direct contact of water with the pipeline leads to higher corrosion. Depth to water information is summarized by pipeline segment in Table 3-3.10.

4.2.3 SEPARATION SEDIMENTS

Separation sediments are low-permeability sediments that presumably will impede the migration of a fuel spill or leak. Consequently, where these sediments exist, underlying aquifers will be less susceptible to a spill or leak. These sediments are deemed Acritical to assessing the risk of potential contamination from the pipeline if a leak were to occur@ (p. 3.3-2). Separation sediments are discussed in a very general way in Table 3.3-9. The occurrence or areal distribution of separation sediments is not presented anywhere in the Application.

4.3 CRITIQUE OF AQUIFER CHARACTERIZATION

The identification of seven different hydrogeologic regimes is a reasonable general representation of most of the aquifer systems along the CCP route. However, this characterization is clearly inadequate as a basis for preliminary scoping and evaluation of the CCP. The characterization of groundwater resources is incomplete, overly simplified, and fails to address many of the aquifer characteristics that represent risk or vulnerability factors.

4.3.1 COMPLETENESS AND CONSISTENCY

The Application identifies seven aquifer types. An omission from this group is the sedimentary deposits of the Ellensburg formation that outcrop east and northeast of the City of Ellensburg and which underlie much of the surface alluvium in the Kittitas valley. Presumably, the CCP will cross portions of the Ellensburg formation, a thick sequence of stream and lake deposited silt, sand and gravel, and pyroclastics (Pearson 1985). This deposit is discussed briefly in the Application (p. 3.3-58) but is not included as an aquifer type even though it is identified by the United States Geological Survey (USGS) in their evaluation of principal aquifers in the state (Molenaar et. al.. 1980). Also, it is not appropriate to include Asole source aquifer@ as an aquifer type. The sole source aquifer designation is a federal regulatory designation that typically requires petitioning from a local group. A sole source aquifer designation does indicate an aquifer is a principal or the only source of water for an area and, if contaminated, would create a significant hazard to public health. However, the designation is not a comprehensive evaluation of aquifer susceptibility or necessarily related to aquifer type. Consequently, use of this designation as an aquifer type is confusing and likely to be misleading to reviewers.

The availability of alternate water supplies should be considered as a vulnerability factor along the entire CCPL route. However, the Cross Valley Aquifer is not the only such area. Large areas of the Snohomish and Yakima basins could be considered equivalent to sole source aquifers. These basins are considered over-appropriated by Ecology and large areas are not readily accessible to public water system infrastructure. Within the Snoqualmie River basin, the North Bend Aquifer has been characterized as the largest aquifer in western Washington (City of North Bend 1998). This aquifer would likely meet the definition of a sole source aquifer, but was not even identified in the Application. Similarly, the Columbia Plateau Aquifer System (including all of Franklin, Grant, and Adams Counties) was proposed as a sole source aquifer by the EPA prior to its designation as a groundwater management area. Eighty-eight percent of potable water supply comes from groundwater in this basin (Ecology 1997).

4.3.2 LACK OF SPECIFICITY

Within the context of the Application, a significant omission from the aquifer type designation is the lack of specificity. Within some aquifer type groups there is considerable variation in hydraulic properties or known changes in geologic conditions that could be indicative of hydraulic property variations. For example, alluvial aquifers are classified together regardless of geographic region; however, even within the Snoqualmie Valley, the alluvium is a Ahighly productive unconfined aquifer upstream of Snoqualmie FallsY(but) becomes less permeable and apparently less productive downstream@ (Turney 1995). Similarly, the Columbia River Basalt group is composed of distinct subgroups with different general hydraulic properties (Whiteman et.al. 1994). In the Kittitas-Ellensburg area, the basalt is likely to be the Wanapum or Grand Ronde Basalt subgroup while east of the Columbia River, the pipeline will intersect the Saddle Mountain Basalt subgroup (Whiteman et.al. 1994).

Depth to water is discussed in the Application and is used in the groundwater resource impact/sensitivity rating in Table 3.3-10. Typically the deeper the distance to water, the less likely leaking product will reach the aquifer or nearby surface water. Consequently, depth to water is an important parameter for evaluating aquifer sensitivity. Unfortunately, the estimates presented in the Application are too general to be useful. For example, the Application characterizes depth to water for some pipeline segments as ranges; between mileposts 16 and 33.7 the depth to water is characterized as 10 ft to 50 ft. This range represents a very large range in aquifer vulnerability. In the Kittitas Valley, the depth to water between mileposts 114.9 and 126.5 is defined as 60 ft to 100 ft. In this segment, a shallow aquifer occurs in the alluvium overlaying the Ellensburg Formation. There are a number of shallow wells in the alluvium (according to Ecology records) that indicate depth to water occurs as shallow as 10 ft below the ground surface. Also, the CCPL makes over 290 watercourse crossings. At most of these crossings, the CCPL will go beneath rivers and streams and actually be submerged below the aquifer water table (Depth to groundwater = 0). These sensitive areas are not addressed in Section 3.3-5 of the Application. Additionally, the Application indicates trench dewatering may be necessary for construction (p. 3.3-73) indicating that the pipeline will be buried beneath the uppermost water table. None of these areas are identified in Table 3.3-10, yet they are areas of high importance with respect to aquifer vulnerability.

4.3.3 PARAMETER: HYDRAULIC CONDUCTIVITY AND TRANSMISSIVITY

Though characterizing the pipeline route by aquifer type has some utility from a conceptual standpoint, it does not provide a strong basis for quantitative assessment of resource sensitivity or provide a basis for evaluating impacts to receptors or cleanup costs. In the context of impact sensitivity and aquifer vulnerability, the most important property of an aquifer will typically be the hydraulic conductivity (a coefficient used to calculate the relative rate of water movement through an aquifer). The Application does not present even a cursory discussion of hydraulic conductivity for each of the aquifer types. There is also no discussion of the variation in hydraulic conductivity within each aquifer type along the pipeline transect. This variation can be significant. The United States Geologic Survey (Turney et. al. 1995) has characterized the areal distribution of hydraulic conductivity within the overburden (alluvium, Ellensburg formation) in the upper Yakima and Kittitas Valleys. These values range from less than 1 ft/day to 100 ft/day. Clearly, characterizing all Upper Yakima and Kittitas Valley soils as alluvium is misleading and will lead to substantial inaccuracy in the aquifer impact assessment presented in Table 3.3-10. Though the Application suggests that aquifer Apermeability@ was characterized (p. 3.3-66), no supporting information is presented in the document, either through appropriate references or a presentation of estimated hydraulic conductivity values. Permeability or hydraulic conductivity is necessary to calculate groundwater travel times. Travel time designations are necessary elements of local well head protection programs for drinking water system supply. For example, the City of North Bend would want the pipeline to be no closer than a one-year contaminant travel time from their well (City of North Bend 1998). A one-year groundwater travel time also defines the Zone 1 groundwater management area specified for well head protection (Washington Department of Health 1995). A travel time-based protective zone around a well head is necessary to give water system purveyors time to respond to an accidental spill. The Application should provide an assessment of whether this requirement is met for water systems along the route. This assessment would require characterizing aquifer hydraulic conductivity.

Transmissivity is the product of the hydraulic conductivity and aquifer thickness. It is typically used to determine the productivity or water transmission capability of an aquifer (Driscoll 1986). Transmissivity is directly related to the value of an aquifer for public water supply; not just current use, but the value of the aquifer for future use. Transmissivity and the value of the aquifer resource should be addressed in the Application but were not.

4.3.4 PARAMETER: MEDIA TYPE

The Application fails to adequately discuss aquifer media type: porous versus fractured media. Similar to hydraulic conductivity, media type has a direct effect on the significance of a pipeline spill. Fractured media (e.g., Columbia River basalt) typically exhibits much greater anisotropy and hetrogeneity than porous media (e.g., glacial outwash). Consequently, it is typically much more difficult to detect impacts and predict transport of contaminants in fractured rock aquifers (Fetter 1993). It is also often infeasible to remediate petroleum product or other non-aqueous phase fluids if they enter fractures. The Application does characterize the Cascade Mountain Bedrock and Basalt aquifer types as being controlled by fractures (p. 3.3-58). The Application even states that groundwater cleanup of fractured bedrock is impractical (p. 3.3-56). However, the technical issues associated with contaminant transport and remediation in fractured rock do not appear to be incorporated into the vulnerability assessment [the Cascade Bedrock is given the lowest index rating value (Table 3.3-9)]. The presence of fractured media should be considered as a separate risk factor in calculating groundwater impact sensitivity.

4.3.5 PARAMETERS: GROUNDWATER FLOW DIRECTION AND HYDRAULIC GRADIENT

Groundwater flow direction is essentially completely uncharacterized in the Application. The statement is made that in Ageneral, groundwater flows from areas of recharge to areas of discharge@ (p. 3.3-54); Atypically, areas of recharge are located at higher elevations, and areas of discharge are at lower elevations." Given the length and complex hydrogeologic terrain traversed by the CCPL, this characterization is inadequate. At the scoping level of the Application, groundwater flow direction is important to identifying potential receptors. Receptors such as Amunicipal and other public water supplies located downgradient of the route are conceivably at risk from a potential petroleum spill@ (p. 3.3-78). The Application appears to have just evaluated receptors downgradient of the pipeline without first determining which direction is downgradient. For example, the Application states that the Acity of Kittitas wells Y are upgradient of the alignment and therefore not at risk from the project@ (p. 3.3-82); and Apotential impacts to water quality from a large spill are possible, however, in surface and groundwater supplies that are downgradient of the pipeline@ (p. 3.3-78). The lack of groundwater characterization in the Application calls into question the accuracy of this conclusion and others like it.

The Application appears to assume that groundwater flow direction will simply follow the topography. This will be true in many locations along the route, however there are likely to be a number of significant exceptions. The Application itself makes reference to one such potential exception when it notes that Athe drier areas of eastern Washington infiltration from flooding streams and rivers may be the primary source of groundwater recharge@ (p. 3.3-54). (Note that the USGS concludes that infiltration from precipitation is the primary source of recharge in this area; Whiteman et. al. 1994.) Actual areas where groundwater flow direction may not follow topography are:

River and stream stretches that are losing or discharging water

Areas near leaking irrigation canals

Areas dominated by irrigation return flows and ditches

Areas near pumping wells.

Hydraulic gradients are also only discussed in the most general terms in the Application (p. 3.3-55). Hydraulic gradient characterization is similar in importance to hydraulic conductivity. These two parameters describe the rate of groundwater flow through Darcy=s Law (Freeze and Cherry 1978). Groundwater flow (and related pure product phase flow) is the primary mechanism that will spread a petroleum impact in the subsurface environment. Stream velocities were calculated in Product Spill Analyses for this expressed purpose. Similar calculations were not presented for groundwater. Groundwater flow direction and rate are essential components to scoping and designing an appropriate groundwater monitoring program especially if the program requires rapid deployment as suggested in the Product Spill Analyses. Groundwater monitoring is a specific mitigation measure proposed in the Application (p. 3.3-78) and is referenced as a response action in the Product Spill Analysis (Application Appendix B-2).

4.3.6 PARAMETER: GROUNDWATER - SURFACE WATER HYDRAULIC CONTINUITY

Hydraulic continuity is the concept of interaction between surface water and groundwater. The concept is important for both water supply and contaminant transport. Hydraulic continuity was the basis for Ecology to deny numerous water right applications in 1996 (Ecology 1998a). Ecology has recently completed a comprehensive review of the subject and issued a draft technical memorandum (Ecology 1998a). From a petroleum leak perspective, the concept is especially important because it addresses the risk of a release to groundwater spreading to surface water, impacting fisheries and other aquatic resources. The Application Product Spill Analysis (Appendix B-2) does not address impacts to surface water through hydraulic continuity with groundwater. However, this scenario actually occurred at Olympic=s Renton spill site where a leak to groundwater resulted in product discharge to the Cedar River in King County. The Application should incorporate the evaluation of hydraulic continuity as a groundwater resource vulnerability factor.

4.3.7 DOCUMENTATION AND REFERENCES

In the beginning of Section 3.3, the Application lists reference sources used to characterize water along the CCPL route. This reference list is completely inadequate. An extensive knowledge base exists on water resources along the route that was not consulted.

The Application does not consider many valuable references concerning geology and groundwater along the pipeline route. Examples of important sources not referenced in the Application include:

Geohydrology and Ground-Water Quality of East King County, Washington (USGS) (Turney et. al. 1995)

Hydrogeologic Investigations in the Upper Snoqualmie Basin (Golder 1996)

City of North Bend Hydrogeologic and Production Well Report (RH2 1997)

East King County Groundwater Management Plan (EKCGWAC 1996)

Hydrology of the Upper Yakima River Basin, Washington (Pearson 1985)

Effects of Hydraulic and Geologic Factors on Stream Flow of the Yakima River Basin Washington (USGS) (Kinnison and Sceva 1963)

The Hydrogeologic Framework and Geochemistry of the Columbia Plateau Aquifer System, Washington, Oregon and Idaho (USGS) (Whiteman et. al. 1994).

Principal Aquifer and Well Yields in Washington (USGS) (Molenaar et. al. 1980).

Some of the references that are listed in the Application are outdated or not relevant. The Application says a Areference source for groundwater@ is Ground-Water Survey of Odessa-Lind Area, Washington (p. 3.3-3). The USGS has had an ongoing study of the Odessa-Lind area in eastern Washington, however, the study area is completely outside and northwest of the CCPL route. Of the three comprehensive data sources cited, one is referenced improperly and another has been superceded. The initial water shed assessment that is referenced appears to be two separate documents; one for the Snohomish and the second for the Cedar River. The 1975 version of AMagnitude and Frequency of Floods in Washington@ has been updated by a 1998 version that has been in progress since 1992. The third Akey@ reference is from 1970. There appears to be a pattern of limited effort to evaluate existing information on water resources in the Application. This limited effort appears to also be apparent in the body of the text and the impact and sensitivity assessment.

The Application also does not present an evaluation of existing well-users based on well logs on file with Ecology. This information is available from Ecology by section, township, and range, and is a common feature of environmental impact statements for large projects that potentially impact groundwater. An assessment of existing well users would provide reliable information on exempt well users along the alignment as well as help better define depth to water. Similarly, the Department of Health has a listing of all public water systems.

Documentation and references concerning calculations and data are essentially missing from the Application. For example, the source of depth to water estimates in Table 3.3-10 is not referenced. It is not clear where the numbers came from. Similarly, in the Product Spill Analyses in Appendix

B-2, the spill volumes and contaminant migration rates in surface water and groundwater are completely undocumented, yet many of the depths appear to be inaccurate. Spill volume calculation methods are discussed, but particular assumptions for each spill are not. One, well documented product spill analysis would be much more useful than the 12 poorly documented presentations that are included in the Application. The lack of documentation in the Application essentially puts a burden on the reviewer to recreate much of the analysis to provide a meaningful critique of much of the material.

4.4 STEP 2: IDENTIFY REGULATORY RESTRICTIONS AND REQUIREMENTS

Regulations have been developed by Ecology and the Department of Health that will have direct bearing on the cost of the CCPL in terms of required mitigation and extent of cleanup. OPL compliance with these regulations is important to maintain a consistent and effective environmental and water use policy. Unfortunately, the Application does not provide a reasonable context for evaluating regulatory requirements associated with the CCPL. Regulatory requirements also changed significantly in 1998. These changes are due in part to water resource planning legislation (HB 2514) and salmon recovery legislation (HB 2496), Governor Locke=s draft salmon recovery plan, and the proposed listing of salmon and steelhead. The Application appears to fail to anticipate these changes or their implication for the viability and cost of the project.

In Section 3.3, Water, the Application discusses applicable regulations. The covered regulatory areas are water rights and instream flow restrictions (p. 3.3-6), Clean Water Act requirements (p. 3.3-6), Model Toxic Control Act (MTCA: WAC 173-340) (p. 3.3-73), public water supply requirements (3.3-78) and well construction requirements (WAC 173-360) (p. 3.3-73). The discussion in the Application is both superficial and incomplete. Consequently, the intent of the CCPL project to strictly comply with applicable regulation and the cost of compliance can not be discerned from the Application.

4.4.1 CRITIQUE OF REGULATORY ASSESSMENT

The Application fails to adequately characterize applicable regulations and describe how these regulations would impact the project. Regulations that pertain to groundwater resources include:

Water quality protection and cleanup regulations

Instream flow and water rights regulations

Federal endangered species act

Public water system regulations

Local water system planning.

4.4.1.1 Water Quality Protection and Cleanup Regulations

Washington State promulgates groundwater quality regulations through WAC 173-200. The groundwater quality standards include non-degradation provisions designed to maintain the highest and best use of the resource. Groundwater cleanup of a spill in strict compliance with WAC 173-200 will typically be a more substantial effort than compliance with MTCA provisions. For example, WAC 173-200 sets cleanup standards based on an excess cancer risk of 1 in 1 million (1x 10-6). MTCA, however, allows for more flexibility (WAC 173-340-700). Though not mentioned in the Section 3.3.5, MTCA applies to soil, groundwater, surface water, and air. Ecology is currently considering revising MTCA including the incorporation of alternate petroleum hydrocarbon standards. Alternative petroleum standards have been in effect on an interim basis since January 1997 (Ecology Publulication No. ECY97-600) yet are not mentioned in the Application. Both MTCA and WAC 173-200 discuss enforcement at the point of compliance (the location where cleanup criterion will be applied); however, this issue is not discussed in the application. Both MTCA and WAC 173-200 allow for setting more stringent cleanup standards based on existing and future beneficial uses that require more stringent protection than provided by human health criteria. Given the presence of listed endangered species in many of the waters traversed by the CCPL, more stringent standards may very well be necessary to protect surface waters in hydraulic continuity with groundwater. This determination will require first a listing of beneficial uses for surface water, a determination of hydraulic continuity, and an evaluation of ecological toxicity. Similarly, MTCA provides for more stringent standards to be established for sub-populations such as Native Americans with a higher degree of potential exposure to some contaminants. Information to determine the necessity of these evaluations is not presented in the Application.

In addition to state standards, Indian tribes can and do set their own water quality standards for both surface water and groundwater. There is no mention of tribal water quality standards in the Application. Also, MTCA does not require that all petroleum be removed following a spill. It is likely that an impacted aquifer that is cleaned up to MTCA cleanup standards will continue to have aesthetic or secondary impacts such as higher levels of dissolved solids. These secondary impacts can impact aquifer use for drinking water and irrigation long after a cleanup is complete. The question remains from the Application, what kind of cleanup can the citizens of Washington expect. The standard of cleanup is of particular concern given that the product spill analyses (Appendix B-2) suggest that much of the contamination will be managed in place without being fully cleaned up.

4.4.1.2 Instream Flow and Water Rights Regulations

Instream flow restrictions (WAC 173-500) are regulated surface water flows in state waters. These restrictions are either a certified water right specified for non-consumptive uses or regulatory prohibitions. The Application does mention instream flow restrictions (Table 3.3-3); however, the significance and context of these restrictions are not put into perspective. Restrictions along the route are currently relatively few; however, this is unlikely to be the case in the future. Ecology currently considers both the Snoqualmie and Yakima basins over appropriated (http://www.wa.gov/esa/strategy/flows.jpg). Also, the Governor=s draft Salmon Plan (Office of the Governor 1998) expressed the intent to implement instream flow regulations on all streams and rivers that contain proposed or listed threatened and endangered species; both the Yakima (Middle Columbia River Steelhead and Bull Trout) and Snoqualmie (Puget Sound Chinook and Bull Trout) have listed species (Jones and Stokes 1998).

Instream flow restrictions are relevant to the groundwater resource in at least two specific ways. First, instream flow restrictions may also result in restrictions on further groundwater development in hydraulic continuity with surface water. An instream flow restriction is typically an indication of a stressed surface water and groundwater resource. Consequently, groundwater in the Snoqualmie and Yakima basins should be considered over appropriated simply because the surface water is over appropriated. Second, an instream flow restriction is an indication that an alternate water supply is not readily available in the vicinity of the designated stream segment. For example, if a pipeline leak occurred in the vicinity of proposed production wells in the city of North Bend or city of Snoqualmie, it is possible that additional groundwater would not be available without further harming the surface water resource. Also, groundwater pumping and treatment could be restricted as a remedy during low stream flow periods.

4.4.1.3 Federal Endangered Species Act

The National Marine Fisheries Service recently listed eight additional salmon and steelhead populations in 1998 including Puget Sound Chinook. Given the high probability of the project impacting endangered anadromous fisheries and resulting in a Ataking@ under the ESA, the project may be required to comply with incidental take provisions of the act. This could require preparation of a habitat conservation plan. The potential and scope of this additional regulatory burden should be integrated into the discussion of environmental consequences and economic viability of the project. A groundwater impact could result in a surface water impact (such as Olympic=s Renton spill) and, consequently, kill or damage endangered fish populations. Aquifers in hydraulic continuity with critical fish habitat should be identified and incorporated into the aquifer vulnerability rating.

4.4.1.4 Public Water System Regulation

The significant and high quality water resources along the CCPL alignment support numerous beneficial uses including potable water supply. Potable water supply is derived either from groundwater wells or from surface water in hydraulic continuity with groundwater. The Application discusses public water systems in Section 3.3.6 and states that none Aof the public sources along the alignment have instituted groundwater or watershed protection programs, wellhead protection programs or other source protection programs.@ This statement is highly misleading. There are extensive water resource planning programs being implemented in the vicinity of the CCP alignment by local municipalities and associations. The CCP project could potentially impact these programs and result in an additional cost burden for local communities.

The State Department of Health (DOH) regulations for public water systems (WAC 246-290) includes the requirements for a water system plan. The water system plan addresses source protection (WAC 246-290-135), which includes wellhead protection provisions (groundwater and spring users), contingency plans (to ensure an adequate supply of potable water), and a watershed control program (for surface water users). Class A water systems meeting the requirements of WAC 246-290-135 need to submit a water system plan. According to DOH (Patterson 1998) the cities of North Bend and Carnation, while currently out of compliance, will be required to submit a well head protection plan and associated requirements when their water system plan is updated (updates required every six years). Similarly, the city of Snoqualmie and other listed municipal systems will also be required to submit a plan. Local water systems could be required to incur a significant additional financial burden in terms of susceptibility assessment and contingency planning due to the pipeline. A number of other groundwater management initiatives are underway in the vicinity of the CCP route. These initiatives include a groundwater management plan (including resource protection provisions) prepared for the East King County Groundwater Management Area (East King County Groundwater Advisory Committee 1996). The Tri- County Water Resource Association (TCWRA) has received a grant from Ecology and is currently implementing comprehensive groundwater, surface water and habitat planning in the Yakima Basin. A similar initiative is underway for the Columbia Basin Groundwater Management Area (Ecology 1997) (including Grant, Franklin and Adams counties) which was designated in October 1997 per WAC 173-100. The results of these studies and management programs could have a significant impact on the pipeline. In the Application there is no mention of the general Ecology watershed planning initiative (HB 2514) or the specific projects being implemented along the pipeline route.

4.5 STEP 3: IDENTIFY AQUIFER USE

The Application discusses water uses along the CCP route. Water rights Aadjacent@ to the right-of-way are summarized by water resource inventory area (WRIA) (p. 3.3-21). The Application also provides a general summary on the type of water use by mile segment (Table 3.3-10) and describes larger public water supplies along the route (p. 3.3-78). Unfortunately, for such an important parameter, this summary is general and incomplete. An assessment of water system use that provides for an evaluation of all water use along the pipeline is important. This assessment should provide for an evaluation of the potential impact to human health as well as the potential cost to mitigate an impact. Specifically, the Application states that OPL will Aprovide alternative water supplies and compensation to the water users until the water supply is restored@ (p. 3.3-38). The Application makes a similar statement relative to Asenior water rights@ (p. 3.3-32). Lack of aquifer use characterization results in large uncertainty in the discussion of pipeline impacts and mitigation and compensation costs.

4.5.1 CRITIQUE OF AQUIFER USE ASSESSMENT

The Application refers to Asenior water rights@ (i.e. p. 3.3-32) and Apermitted water rights@ (i.e. p. 3.3-25). It is not clear what is meant by these references. Permitted water rights normally refer to a potential user who has had an application approved by Ecology, but has not yet put the water to beneficial use (at which time Ecology will issue a certificate). The number of permitted users along the pipeline alignment is relatively few. In most of the WRIAs, the majority of water users do not have a certificated water right. Most or many water right holders have a water rights claim, which must be verified in a formal adjudication. An adjudication will likely determine that many of these claims are valid with a priority date senior to users that currently hold a valid certificate. The term Asenior@ with reference to water rights is a relative term. Technically, there is only one Asenior@ right within a basin. Clearly it is important that all valid claims, permits, and certificated water rights be compensated as part of a compensation plan. It is not clear, however, how the plan would determine which of the numerous water rights claims are valid and how these claims would be compensated. The Application should clearly state what water use groups are covered by the compensation plan. The current vague reference to so called Asenior@ users or permitted rights could ultimately result in the vast majority of users not being covered.

The Application also does not address exempt well users. Users who withdraw a minimum amount (less than 5,000 gallons per day) and for certain specified uses are exempt from water right permit requirements (RCW 90.44 and 90.03). Over 90 % of all wells drilled each year are for exempt uses (Ecology 1998b). In many areas, the majority of users will be exempt single or multifamily domestic wells. In some or potentially most areas, the greatest number of water users will be exempt. For example, in the Cross Valley Water District, about half (at least) of the estimated 22,000 water users are on exempt wells (Maltby Area Residents December 17, 1998). A reading of the Application indicates these users are not even considered in the scoping and evaluation of the CCP. Will OPL compensate these exempt users from CCP construction and/or operation impacts?

The Application does not mention the presence of tribal rights. Northwest Indian Tribes have off reservation instream flow rights related to their treaty fishing rights. Though not typically quantified, these rights are likely to be quite substantial and possess a priority date of time immemorial. The extent of Yakima Indian Nation rights in the Yakima River basin have been affirmed in the only ongoing basin adjudication in the state (Department of Ecology vs. Yakima Reservation Irrigation District: 1993). The Application does not mention these rights, how they would be effected or whether these rights would be addressed in the Acompensation plan." Will OPL compensate tribes for losses related to their tribal water rights due to CCP construction and/or operation impacts?

The Application also does not adequately describe public water systems in the vicinity of the pipeline, or how the project would affect these water systems. The Application also does not refer to the Snoqualmie Pass Utility District that reportably supplies water to over 200 users from two wells near the pass. The East King County Regional Water Association has submitted an application to use up to 41,600 gpm (Ecology application # G1-27384) in the upper Snoqualmie Valley. A preferred alternative to develop this resource is to pump groundwater into the Snoqualmie River above Snoqualmie Falls and remove the water from the river downstream near Duvall, WA (Golder Associates and HDR Engineering 1998). Five of the twelve well locations proposed by the alternative are within 1,000 ft of the pipeline (Golder Associates and HDR Engineering 1998). A spill into the Snoqualmie River could be catastrophic for this project. Presumably, there are numerous other municipal water purveyors and projects that have not been specifically identified. The human health and economic consequences of a leak or spill to these purveyors is dependant on the proximity of the water supply to the pipeline, the depth of the well, the type of well or water intake, and the number of connections. The extent and cost of mitigation required to protect water suppliers is dependant on providing this information; information that is readily available from the public record.

In addition to municipal suppliers, there are potentially numerous small water systems along the pipeline route. The Application does not make any reference to small Class A systems (typically systems with 15 or more connections) or Class B systems (typically systems with less than 15 connections). There is no way to get an understanding for the number of these smaller systems along the pipeline route from the Application and, therefore, no way to determine the potential impact of the pipeline. For example, the Tokul Community Water System has a water right claim with a priority date of 1915 from an unnamed spring near the mouth of Tokul Creek (located in Township 24 North, Range 8 East, Section 18). This water system is not mentioned in the Application. Will they be compensated by OPL due to CCP construction and/or operation impacts?

The description of water uses in Table 3.3-10 is limited to irrigation, public supply, domestic, or industrial. The descriptions are not consistent with Ecology designations used for certificates, permits or claims. There is no mention of fishery (hatchery) uses or stock watering uses. Hatchery use could potentially be the most susceptible from a water quality impact. The Washington Department of Fish & Game has four certificated water rights for the Tokul Creek Hatchery from

Tokul Creek near its mouth and an unnamed spring (located in Township 24 North, Range 8 East, Section 19). The United States Geologic Survey (Whiteman et.al. 1995) lists hatchery or aquaculture uses as the largest water use in the Upper Snoqualmie River Basin, and a significant water user in the lower Snoqualmie Basin. There are numerous stock watering uses along the pipeline route according to Ecology records. Without discussing all water uses along the pipeline corridor, it is not possible to evaluate the environmental consequences of the project or the scope and cost of mitigating measures. It is also not clear if non-consumptive uses such as hatcheries, irrigation and stock watering, would be compensated under the compensation plan discussed in the Application.

4.6 STEP 4: DEVELOP AN AQUIFER IMPACT/SENSITIVITY RATING SCHEME

The Application presents a sensitivity and potential impact rating for individual mile segments along the CCP route (Table 3.3-10). The purpose of the rating is to Aassess which aquifers are the most critical and where additional protective measures and monitoring are needed to prevent and/or minimize impacts@ (p. 3.3-66). The rating system Adepends on the groundwater conditions and the uses of the aquifers@ and Aconsiders the value of the aquifer resource, the permeability and separation distance of the geologic materials@ (p. 3.3-66). The ratings table (Table 3.3-10) actually has four parameters:

Groundwater regime (values range from 1 to 4)

Groundwater use (values range from 0 to 2)

Depth to groundwater (values range from 1 to 3)

Separation sediments (values range from 1 to 3).

Each of these parameters has an index rating value shown in parentheses above. These values are assigned based on the characterization of groundwater resources. All of these characterizations are qualitative with the exception of depth to water, which is based on specific depth ranges. An overall rating for each mile segment was attained by totaling scores from the four parameters.

The ratings range from a low of 5 (in fractured bedrock at and east of Snoqualmie pass) to a high of 11 (in the Snoqualmie Valley directly above and below Snoqualmie Falls). The ratings have a mean of 7.8 and ratings Aof 10 or greater can be considered significantly more sensitive than the mean or typical conditions@ (p. 3.3-67). Certainly, the bedrock aquifer at Snoqualmie pass is highly susceptible to an impact from a spill, but it only has a A5@ rating. Petroleum product that enters these fractures would be very difficult to cleanup and could have a major impact on the local water supply utility.

4.6.1 CRITIQUE OF AQUIFER IMPACT/SENSITIVITY RATING SCHEME

The rating system lacks a reasonable technical foundation and, as it is presented in the Application, appears to be essentially an arbitrary assessment of the resource sensitivity. The system is, therefore, inadequate as a tool to define the actual critical aquifer areas and determine necessary monitoring and mitigation. The primary deficiencies are discussed below.

4.6.1.1 Approach

The impact sensitivity assessment does not reference existing models either from peer reviewed literature or regulatory agencies. For example, Ecology has a specific assessment process for evaluating impacts from an oil spill (WAC 222-16). This assessment includes eleven different parameters, ten of which are associated with the quality of the effected resource. The federal Department of Interior (pursuant to CERCLA) and the National Oceanic and Atmospheric Administration (NOAA) (pursuant to the Oil Pollution Act) have developed natural resource assessment models (Stewart 1995). The Application indicates that the assessment includes the value of the aquifer resource (p. 3.3-66) however no valuation scheme is discussed. The Department of Commerce has published a thorough evaluation on groundwater resource valuation (National Research Council 1997). The specific methodologies for the impact assessment should be referenced to provide confidence that the analysis is objective and well reasoned.

4.6.1.2 Quantitative Methods

The quantitative approach used in the impact assessment is both biased and statistically unsound. The impact rating is based on a rating of four different parameters. The range in parameter values vary from 4 points for groundwater regime to 3 points for separation sediments and depth to water to 3 points for groundwater use. The rating scheme essentially weighs groundwater regime as the most important parameter, because it has the largest point range. From an impact sensitivity standpoint, separation sediments or aquifer use should probably have the highest rating of the parameters listed in the Application depending on the objective of the rating scheme. In any event, the logic of the parameter selection and weighting scheme for the groundwater resource rating is not discussed in the Application nor is it apparent from the context of the discussion.

The depth to water index rating values do not appear to have a technical justification. The largest depth to water (> 100 ft) is given the lowest rating of 1. Shallow water tables are given the highest rating of 3. While shallow water tables are most likely to be impacted from a spill, especially a rupture that is quickly detected, they are also the easiest to remediate. Because petroleum product is lighter than water, the shallow water table essentially blocks the downward movement of the free phase product. Cleanup actions can include excavation of a majority of the source and installation of shallow extraction and deliver systems. If the water table is deeper, the free product penetrates deeper and a significant mass is trapped in the unsaturated zone in residual saturation (Mercer and Cohen 1992). Residual saturation levels for petroleum products in the unsaturated zone will vary with soil type, but can exceed 30 % of the pore space. For a spill with a source area that includes a 100 ft of trench 5 ft wide, over 16,000 gallons of product could be held in residual saturation over a 50 ft unsaturated zone (assumes the entire area beneath the source area is impacted; porosity = 30%; residual saturation = 30% of porosity). The residual product will serve as a long-term source to groundwater through slow dissolution of the product into infiltrating water. The deeper residual product will not be able to be excavated and other remediation efforts will be very difficult and costly due to the greater depth. In such situations, the length and cost of remediation can be substantial. The Application does not appear to consider the cost, duration and difficulty of remediation.

Other depth to water related impacts should also be discussed. Shallower water is more susceptible to construction dewatering, corrosion, and interruption of groundwater flow path impacts. Shallow groundwater is also more likely to be in hydraulic continuity with surface water and contribute to slope stability hazards. In summary, vaguely defining depth to water for very long pipeline segments (averaging over 6 miles in length) is not adequate to characterize the related risks and impacts associated with this parameter.

The Application states that a groundwater sensitivity rating Aof 10 or greater can be considered significantly more sensitive than the mean or typical conditions found along the pipeline corridor@ (p. 3.3-66). The apparent statistical significance associated with the number 10 that is implied by this statement is suspect. The value of 10 appears to be a qualitative assessment, not a statistical quantitative assessment as implied by the text. A determination of statistical significance requires the specification of a significance level (Helsel and Hirsch 1992). Significance levels are typically set at 5 percent (alpha = 0.05) by Ecology for groundwater cleanups (Ecology 1992a); however, there is no reference to a significance level in the text. Also, the qualitative and seemingly arbitrary nature of the rating scheme in the first place makes application of a quantitative determination of vulnerability inappropriate.

4.6.1.3 Scope

The assessment should consider at least the following characteristics: the vulnerability of the resource, scarcity of the resource, and sensitivity of receptors. Specific parameters to describe these characteristics are readily available from existing information sources.

Vulnerability of the resource should include parameters that are related to the likelihood of a petroleum release to spill to migrate and spread in the subsurface and the difficulty in remediation. Relevant parameters include:

Hydraulic conductivity

Hydraulic gradient

Hydraulic continuity

Media type

Depth to water

Stratigraphy (presence of controlling geologic layers including separation sediments).

The Application includes depth to water and stratigraphy and media type (incorporated into groundwater regime); however, this characterization is typically undocumented and extremely general in nature. There is no characterization of hydraulic conductivity and gradient in the Application.

Scarcity of the resource includes parameters that relate to the availability of water. Relevant parameters include:

Regulatory restrictions and designations

Comprehensive or growth management plans

Water resource management plans.

Though the Application discusses instream flow restrictions and water rights, it does not incorporate available information on water resource availability from Ecology or other sources in its impact assessment.

Sensitivity of receptors includes a thorough characterization of water users. This should include non-consumptive uses such as fishery migration and propagation and all consumptive uses:

Consumptive uses

Large municipal systems
Small class A and B systems

Exempt users
Tribal (and other sub population) users

Non-consumptive uses

Fishery migration and spawning
Hatchery use
Irrigation
Stock watering
Recreation.

This information is available from Ecology, the Department of Fisheries, and the Department of Health as well as local sources, and federal agencies such as the United States Geologic Survey. The Application does not characterize exempt uses or small water systems at all. The impact rating uses terminology such as Aunknown@ (Table 3.3-10). It is possible or indeed likely that the majority of potable water supply adjacent to the CCP route is currently completely uncharacterized and is certainly not reflected in the impact rating. With the exception of general irrigation and industrial classifications, non-consumptive uses are not considered in the impact rating. Due to the issue of hydraulic continuity and the fact that many of the smaller streams that support fisheries will be completely supplied by groundwater from base flow during summer and fall months, the presence of sensitive surface water uses, such as fisheries, needs to be incorporated into the impact rating.

4.7 STEP 5: IDENTIFY CONSTRUCTION, REPAIR, AND PIPELINE ABANDONMENT IMPACTS AND MITIGATION

This section presents a discussion of CCP construction impacts and mitigation. The pipeline discusses construction and operation impacts together. Impacts described in Section 3.3.5.2 that are related to construction are primarily excavation interruption of groundwater flow paths, and dewatering.

4.7.1 EXCAVATION IMPACTS

Excavation impacts include incidental construction spills and encountering existing subsurface structures such as underground storage tanks and old wells. Spills of hazardous material are assumed to be minor such that they would not impact groundwater. No specific mitigation is proposed for preventing construction spills in Section 3.3.5.3 (Groundwater Mitigation Measures) or in Section 1.4.7.5 (Groundwater). Spills Awill be cleaned up by construction crewsY dissipating rapidly from natural processes, including dilution, dispersion, and advection@ (p. 3.3-73).

Given the scope of the project, the CCP can be expected to encounter existing underground structures such as USTs or abandoned wells. Mitigation for these circumstances includes proper disposal procedures and rerouting of the pipeline (p. 1.4-18).

4.7.2 INTERRUPTION OF GROUNDWATER FLOW PATHS

Trench backfill will generally consist of native soil excavated from the trench. Where over consolidated soil or low-permeability soil occur, the backfill will likely have an appreciably higher permeability than the native soil. This situation could lead to preferred flow paths within the back fill causing a higher risk factor and possibly impacting recharge patterns.

When low-permeability soils are encountered, the trench will be lined with low-permeability material and the backfill will be compacted. Compaction will be designed to match the overlying soils. Also, the Application states that in Asensitive areas with confirmed well-drained soils, impermeable soils will be employed that will prevent petroleum products from escaping the trench@ (p. 3.3-77).

4.7.3 DEWATERING

Dewatering is apparently anticipated for stretches of the CCP route where shallow groundwater is encountered. Mitigation for dewatering is restricted to rerouting the pipeline around areas that will require large volume of dewatering.

4.7.4 CRITIQUE OF CONSTRUCTION REPAIR AND ABANDONMENT IMPACTS AND MITIGATION

The construction impacts and mitigation assessment for groundwater does not provide a basis for evaluating if impacts will be significant and if significant mitigation and associated costs will be required. The Application should be able to provide a general scope in terms of the magnitude of impacts; however this is not done. There also is no mention about the potential impacts during repair and abandonment. Repair and abandonment actions could have equal or greater impacts than installation of the pipeline. It is not clear from the Application if OPL has considered the impacts and costs of abandonment in evaluating the pipeline.

Incidental spills during construction could potentially be significant depending on the volumes of fuel, lubricants, solvents, and other similar material present. The fact that OPL does not consider construction related impacts to be significant suggests a caviler attitude to potential aquifer impacts. Some constituents that will be spilled may biodegrade or disperse naturally; however, other constituents will be persistent and dissolve in groundwater well above MTCA cleanup standards.

The potential impacts from construction spills can not be evaluated without some idea of the quantity and type of chemicals that will be used at the construction sites. Finally, OPL will have to conform to Ecology spill reporting requirements and state groundwater and soil cleanup standards.

If USTs or old wells are encountered along the CCP route, the OPL should be required to comply with state UST regulations (WAC 173-360), MTCA (WAC 173-340) and well regulations for abandonment (WAC 173-200-160). If mitigation is avoidance, the Application should discuss the likely delays and costs to the project along with the likelihood of encountering these obstacles. If the CCP uncovers an obstacle and chooses to reroute the pipeline, will they be responsible for complying with applicable regulations mentioned above? Will OPL be responsible for remediating existing groundwater and soil contamination on the right-of-way? There would appear to be a high likelihood of soil contamination along the abandoned railroad right-of ways. Was this considered?

Interruption of groundwater flow paths is a potentially significant issue. The mitigation measures described in the Application may be appropriate to address this issue. The primary problem with the Application assessment is that it is not possible to evaluate the extent of this problem or the need for mitigation. The presence of shallow groundwater, coarse surface soil, or low-permeability surface soil should be described in Section 3.3-5. This data could then be used to evaluate the potential construction impacts related to interruption of groundwater flow paths. Currently, this is not possible. Finally, if backfill compaction is performed, what testing and compaction standards will be applied? Compaction may be much more difficult during wet periods. Consequently, this requirement could effect the construction schedule, especially when combined with fish and sensitive species construction window=s requirements. Note also that the draft EIS recommends additional mitigation measures in the form of flow barriers in trench backfill at stream crossings (Jones and Stokes 1998).

Dewatering impacts could have a significant impact on the pipeline. Dewatering could result in reduced base flow to streams and water quality impacts from the discharged water. Currently, the only mitigation for encountering areas where high volume dewatering is needed is avoidance. If avoidance is seriously being considered, than the Application needs to provide a detailed assessment of potential areas where dewatering may be necessary. Avoidance or rerouting could stop the project and result in significant project delays and costs. Once again, this information could follow from the aquifer characterization section if it was done properly.

4.8 STEP 6: IDENTIFY OPERATION IMPACTS AND MITIGATION

The Application discusses both impacts and mitigation to groundwater.

4.8.1 IMPACTS

The primary operation impacts to groundwater are from leaks and spills from the CCP. The pipeline specifically mentions impacts to Aexisting and senior water right holders@ and the ACross Valley Sole Source Aquifer." Within Section 3.3-5, the Application does not actually do an impact assessment from operations beyond suggesting that groundwater uses are at risk. Corrosion is also listed as a groundwater impact (p. 3.3-74), primarily due to shallow groundwater. Seasonal or perennial submersion of the pipeline apparently leads to higher corrosion rates. The Application does not define what groundwater characteristics lead to accelerated corrosion, what the added risk is, or where the pipeline may encounter these conditions.

Though not referenced in Section 3.3-5, the Application also presents AProduct Spill Scenarios@ in Appendix B-2. The spill scenarios are very general and lack any specific technical documentation and are, therefore, of limited use. They do indicate that groundwater resources are likely to be impacted by CCP operation and that the impact can be rapid. For example, the Application Appendix B-2 presents a spill scenario at Harris Creek (approximately MP 19) (p. A-16). The subsurface infiltration rate of diesel fuel is estimated to be 1 ft/hour in the coarse alluvial soils. At this rate, a deep aquifer would also be easily and quickly impacted especially by gasoline, which has a viscosity of approximately 0.45 cp compared with a diesel viscosity of greater than 1 (Mercer and Cohen 1990). Lower viscosity of a fluid results in a higher hydraulic conductivity and a faster migration rate (Freeze and Cherry 1978).

The product spill scenarios also indicate that petroleum product can migrate horizontally with groundwater flow at a relatively rapid rate. For example, in the I-90 spill scenario (p. A-22 of Appendix B-2), a rupture of the pipeline occurs. The pipeline is immediately shut down with a total spill volume of 20,000 gallons. OPL is notified within fifteen minutes and cleanup contractors arrive at the site within 4 hours. Still, under these fairly optimistic conditions, the Application maintains that a sheen of gasoline is detected on the water table 50 ft to 100 ft downgradient of the spill site.

Some of the product spill scenarios do not appear to be realistic. For example, the Columbia River Crossing spill scenario (p. A-38 of Appendix B-2) is caused by a leak. The leak is detected in 72 hours (the assumption for all leak detection) by random observation and reporting. This appears unlikely for the Columbia River Crossing given the depth of burial, the size of the river, and remoteness of the location. Also, there are no environmental impacts that require remedial action for this scenario and no discussion of the impacts of pipeline repair. This scenario appears to be a best case as opposed to a Areasonable worst case@ scenario.

4.8.2 MITIGATION

Groundwater mitigation measures for CCP operation are discussed in Section 3.3.5.3 (p. 3.3-76). Mitigation concepts are also discussed in Section 1.4 and occasionally discussed throughout the text in Section 3.3-5. With some exceptions, mitigation for groundwater appears to be related to general Abest management practice@ (BMP) actions. These include containment systems around pump stations, minimizing block valve locations, especially over the Cross Valley Aquifer (p. 3.3-77), deeper burial of the pipeline, cathodic protection, smart pig monitoring, etc. The application of BMPs is only discussed generally. There is no specific application for pipeline segments identified in the impact rating evaluation with the exception of the Cross Valley Aquifer. The Application mitigation measures need to be directly related to an improved aquifer vulnerability assessment to be viable. Exceptions to this procedure should be identified and justified in a revised Application.

In addition to these BMP type mitigation practices the Application proposes a compensation plan to Aprotect existing and senior water right holders.@ The Application mentions the development of a specific monitoring plan for the Cross Valley Aquifer to Ainsure adequate response time.@ This plan will apparently include some groundwater monitoring (p. 3.3-78).

4.8.3 CRITIQUE OF OPERATION IMPACTS AND MITIGATION

4.8.3.1 Impacts

The impact assessment in the Application should provide a summary of the conclusions of the product spill scenarios in Appendix B-2. The product spill scenarios should present a documented and referenced quantitative evaluation of Areasonable@ worst case conditions. The current spill scenarios do not even include a groundwater impact closely related to the impact that did actually occur at the Renton Pumping Station in about 1986.

A quantitative spill scenario should include three components: a description of the source, contaminant fate and migration, and exposure to receptors. The source of the spill is poorly documented in the product spill scenarios. The amount of product spilled from a rupture is primarily dependent on the flow in the pipeline, the time to detect the rupture and close the block valves, the distance between block valves, and the percent drain down of product in the pipeline. Assuming flow of 110,000 bbl/day (3200 gal./min.), 4 min. to detect and close the valves (assuming automatic shutdown), an 8-mile distance between block valves (p. 2.9-8), a 14-inch diameter line, and 30 percent fluid loss (for rolling topography and a leak near mid-height of the pipe) results in a release of 114,000 gallons. The office of Pipeline Safety database shows the mean spill volume is about 100,000 gallons for 8-inch to 12-inch product pipelines. Major ruptures result in Areported@ spill volumes of 300,00 to 1,700,000 gallons. Reported volumes can be about half of the actual volume spilled (Mastandrea, personal communication 1999). The Application should explain the bases for the rupture release volumes used in the spill scenarios by specifically identifying each of the controlling parameters.

The amount released during a slow leak is primarily dependent on the leak detection system. Apparently, the SCADA leak detection system can detect a leak of less than 1% of flow, while hydrostatic testing can pick up a leak as low as 10 gallons per hour, depending on valve spacing. Inventory control is reportedly capable of detecting leaks of 0.1% of flow or greater. The ability to detect a leak by scheduled or unscheduled observation is more difficult to identify since it depends on surface conditions (snow, buildings, paved surfaces, etc.) and the rate at which petroleum flows along the trench and enters the ground in contrast to rising to the surface.

For conditions of moderately permeable soil, leak rates of 0.1% of flow appear likely to be sustainable for months and perhaps a year or more. For example, the source of the Renton pump station leak was not conclusively determined for 10 years according to an Ecology fact sheet on the spill published in July 1996. Similar to ruptures, the Application should explain the bases for the chosen leak rates and durations in relation to the local geologic and land use conditions, reliability and response times associated with specific detection methods, and consideration of pipeline size and flow rate.

Contaminant migration should take into account the basic concepts of contaminant fate and transport. If the spill is of sufficient quantity to reach the water table, the analysis should assume a free product source with concentrations at the solubility limit. Migration of the plume should take into account advective flow at a minimum. A more realistic scenario can include dispersion and biological decay and retardation (Fetter 1993). In the alluvium in Snoqualmie Valley, average advective migration rates can be calculated from data from Turney et. al. (1995) to be about 300 ft/year for the upper valley in the alluvium. Migration rates will be much higher locally and close to wells, creeks, rivers and other discharge points.

The product spill analysis does not consider the impact to sensitive receptors in general. The impact should assume a domestic well use and groundwater discharge to a small creek at a location where salmon spawning habitat exists. Exposure point concentrations should be evaluated through appropriate modeling.

4.8.3.2 Mitigation

Presumably mitigation should be related to the impact sensitivity rating. This was not done in the Application. For example, the Cross Valley Aquifer area has a impact rating of A10@, less than much of the alluvial aquifer in the Snoqualmie valley which has a rating of A11@. However, the only specific and extensive mitigation measures proposed for the CCP are over the Cross Valley Aquifer, which has a high rating primarily because of its designation as a sole source aquifer. The impact rating system should be the basis for proposed mitigation measures. All portions of the pipeline with high sensitivity ratings should have appropriate mitigation measures that include the suggestions for the Cross Valley Aquifer.

Mitigation for the Cross Valley Aquifer is presented on p. 3.3-75. One mitigation measure mentioned is that Athe construction and operation of the proposed pipeline will meet or exceed industry standards, minimizing any potential impact on the Cross Valley Aquifer.@ Meeting industry standards should not be considered a mitigation option.

The Application does indicate that mitigation for the Cross Valley Aquifer will include a monitoring plan that includes groundwater monitoring (p. 3.3-78). Similar monitoring plans should be included for all aquifer segments that have a similar sensitivity. Based on the current impact assessment, additional areas would include portions of the Snoqualmie Valley, the Kittitas Valley, and the Columbia Plateau Groundwater Management Area west of the Columbia River.

The Application states that Avalve and pump stations will be kept to a minimum at the most sensitive pipeline segments@ (p. 3.3-77). According to the Application=s sensitivity rating, the most sensitive pipeline segment is the area around North Bend (rating 11). Yet, this area has six block valves within a 13-mile segment (p. 2.9-8), the highest density of block valves. This discrepancy calls into question the decision process used in the pipeline scoping employed for the Application and raises doubts about the actual application of mitigation measures that are not specifically described for specific locations.

The Application states that increased line monitoring will be employed in the most sensitive pipeline segments (p. 3.3-78). Since this measure is for groundwater mitigation, presumably the text is referring to the impact sensitivity ratings in Table 3.3-10. The Application does not state what is considered as Athe most sensitive pipeline segments@ or what increased line monitoring will be.

A major part of the groundwater mitigation is the compensation plan. Unfortunately, the Application is not specific on how this plan would be implemented and who it would apply to. Would all water right claims, permits, certificates and applicants be eligible? Would non-consumptive uses be compensated? Would tribal rights be compensated? How would compensation be calculated? These questions need to be answered in a revised Application.

4.9 CASE STUDY: KITTITAS VALLEY

The cursory evaluation of water resource uses and aquifer characterization in the Kittitas Valley has led to an underestimation of the potential impact of the CCPL. The Kittitas Valley relies heavily on both groundwater and surface water resources to support its agricultural economy and the natural resources of its river system.

4.9.1 AQUIFER CHARACTERIZATION

According to the Application (Figure 3.3-6), the CCPL intersects two groundwater regimes in the Kittitas Valley between approximately Swauk Creek to east of the City of Kittitas. These groundwater regimes are the Columbia River basalt and alluvial deposits. This characterization (e.g. groundwater regime) is a primary representation of sensitivity in the Application. Additional detail is necessary to adequately evaluate the sensitivity of this aquifer system to a pipeline leak or spill. This detail includes identifying important aquifers and their characteristics. Detail that was not included in the Application is discussed below.

In the Kittitas Valley, there are three basic aquifer systems as defined by Owens 1995. These aquifer systems are the alluvial aquifer, the Upper Ellensburg Formation, and the Lower Ellensburg Formation (consisting of Yakima basalt). The US Department of Interior (1999) provides a similar classification. The alluvial aquifer system is an important aquifer system for shallow wells, however the other two aquifer systems are more transmissive and typically supply larger water users. Each of these aquifer systems are important and have different characteristics that affect their susceptibility. The basalt aquifer consists of very permeable interflow zones. Folding and faulting of the basalt exposes these interflow zones at valley margins or ridges such as at Swauk Creek (note that the basalt at Swauk Creek is not identified in the groundwater regimes characterization on Figure 3.3-6). At these locations, rapid infiltration of water from irrigation canals or streams can occur. Similarly, large volumes of product could also infiltrate into the basalt. The alluvial aquifer system consists of a heterogeneous mixture of loess, fluvial and colluvial material with interbeds of coarse gravel, cobbles, sand and silt (Owens 1995). The alluvium can be up to 100 ft thick but is often less than 10 ft thick. Groundwater flow direction in the alluvial aquifer will be influenced by irrigation activities and locally will be different then the underlying Ellensburg formation.

The underlying Ellensburg formation is briefly discussed in the Application, but is not identified as a separate groundwater regime. The formation is considered to contain the most groundwater within the valley (Owens 1995). The Ellensburg Formation consists of cemented (tightly packed) alluvial deposits and mudflows. Though the Application states that the City of Ellensburg wells tap the alluvial aquifer (ASC p. 3.3-81), water well logs in Ecology files suggest at least some of the City=s water supply is from the Ellensburg formation. The hydraulic characteristics, groundwater flow direction (which could be different than the alluvial aquifer) and occurrence of the Ellensburg formation should be described in the Application so that a decision maker can evaluate its aquifer sensitivity.

Also, within the upper Yakima Basin and Kittitas Valley, a number of specific groundwater basins have been identified (US Department of Interior 1999, Owens 1995, Kinnison and Sceva 1963). None of these basins or their specific aquifer properties was identified in the Application.

4.9.2 WATER USE

Water use in the Kittitas valley is not described in sufficient detail in the Application to evaluate the likely impact of a leak on the environment, the human health and the economy. Groundwater use in the Yakima valley is primarily for irrigation uses. Municipal and domestic groundwater uses are similar in magnitude. Stock watering and fish rearing are other uses. Water diversions for agriculture and fish rearing are important uses of surface water. The only specific discussions of water uses in the basin are for municipal uses for the Cities of Kittitas and Ellensburg.

Single family domestic uses are potentially at high risk because they are typically shallow wells, often less than 50 ft deep. However, the Application does not define the proximity or number of wells that are within a susceptible distance (e.g., a one year groundwater flow travel time) of the pipeline. Depth to groundwater is also incorrectly defined as being either 60 to 100 ft deep or approximately 100 ft deep throughout much of the valley (ASC Table 3.3-10).

The definition of agricultural uses is particularly deficient in the application. Stock watering uses are not mentioned, but this water use is common in the valley based on Ecology Water Rights Application Tracking System (WRATs) database. Also, the location of major agricultural diversions are not identified for either surface water or groundwater. Many of these diversions would be impacted if a spill was to occur. For example there are numerous diversions on the Yakima River downstream of the Yakima River and Swuak Creek crossings. Based on assumptions in the Application=s own product spill analyses (ASC Appendix B-2) it is likely that these diversions would be impacted. The Kittitas Reclamation District, the Cascade Irrigation District, and the Ellensburg Water Company manage agricultural diversions (Owens 1995). The specific diversions, the uses of these diversions and their susceptibility needs to be defined in the Application.

Also, the Application mentions that the Yakima River basin is undergoing an water rights adjucation and that water resources are over appropriated. However it does not discuss how a pipeline leak would impact this already overburdened resource. Finally, the Yakima Tribes are a senior water rights holder in the basin. The nature of their water rights and how they would be affected has not been discussed.

4.9.3 SENSITIVITY INDEX

The sensitivity index rates groundwater resources in the valley as an 8, 9, or 10. The technical basis for the rating system is suspect (i.e. water use is used as a sensitivity parameter but is not adequately characterized). Consequently, it is not clear that there is basis for excluding some parts of the valley from the most sensitive rating of 10.

4.9.4 REGULATORY PROGRAMS

Construction and operation of the pipeline should be consistent with federal, state and local management of resources. There is almost no discussion of the extensive water management programs being conducted in the Yakima Basin and Kittitas Valley. Specific programs and or regulatory initiatives that may be impacted by the CCP include:

The Yakima Fisheries Project (BPA and Yakima Tribes)

Columbia River Fish Management Plan

Yakima River Water Conservation Project

Federal Agricultural Conservation Program

Yakima Valley Conference of Governments= Yakima River Basin Water Quality Plan

Yakima River Operation management

Yakima Basin Water Rights Adjudication

Tri-County Water Resource Agency Watershed Management Plan

Local municipal well head protection programs.

The pipeline needs to be developed in consideration and coordination with these local plans. However, if the applicant is not aware of the management, legal and regulatory initiatives along the pipeline route, then it is impossible for the project to address these concerns.

4.9.5 IMPACT EVALUATION

Potential impacts from a spill or leak will have a significant impact on human health, the environment and in the Kittitas valley, the agricultural economy. An example of the potential impact is presented in the Swuak Creek spill evaluation presented in a separate chapter of this report. Specifically, fisheries and agricultural diversions would be significantly affected when there is a spill at the Yakima River crossing or Yakima River tributary crossings. These impacts are either not discussed or not characterized accurately. Shallow groundwater impacts could have a significant effect on domestic well users and agriculture. Single domestic wells are a primary water source in many areas of the valley, but the Application does not identify these areas.

Finally, the toxicity of petroleum products to water uses in the valley are not adequately evaluated.

The impact of petroleum on crops grown in the valley or on irrigation systems is not presented. Similarly, the impact to crops caused by the release of metals from aquifers undergoing biodegradation of petroleum is not addressed. The ecological toxicity to fish, invertebrates, or livestock and other mammals is also not quantified. Consequently, even if the volume, timing and migration of a product spill was adequately characterized, the actual impact to the environment and the agricultural economy would still remain uncharacterized.

5.0 SURFACE WATER IMPACTS

5.1 INTRODUCTION

The revised Application for includes a review and evaluation of surface water issues. The scope of the presentation on surface water covers three general areas, existing resources, project impacts and mitigation. This chapter presents a focused review of the adequacy of the characterization of the impacts to surface water from CCP construction and operation.

Impact to rivers and streams can typically occur at CCP stream crossings or through discharge of impacted groundwater to streams where hydraulic continuity exists. Impacts to surface water due to hydraulic continuity with aquifers are addressed in the chapter on aquifer impacts. Consequently, this chapter will focus on the more direct impacts to surface water at stream crossings and the propagation of these impacts downstream. Significant impacts from CCP operation and construction will also occur to wetlands. These impacts are addressed in the chapter on wetland impacts prepared by Council for the Environment.

Surface water along the CCP is critical for habitat for endangered species and other wildlife, potable water supply, recreation and general quality of life. At stream crossings, the CCP will come into direct contact with these resources during construction, during spills and leaks, during repairs and ultimately during pipeline decommissioning.

Incorporating information on surface water is essential for proper evaluation of pipeline impacts and identification of appropriate mitigation. In the Application, this process is both incomplete and difficult to follow. Also, there is not a clear link between surface water characteristics and use and proposed mitigation. Surface water characterization should include the following steps:

Step 1: Characterize surface water in the vicinity of the pipeline route

Step 2: Identify regulatory restrictions and requirements

Step 3: Identify aquifer uses

Step 4: Develop a sensitivity rating scheme based both on surface water characteristics and uses consistent with existing regulations

Step 5: Identify potential construction impacts to surface water and use the sensitivity index to develop mitigation measures

Step 6: Identify potential operation impacts to surface water and use the sensitivity index to develop mitigation measures.

Each of these six steps are discussed below. This discussion includes a summary and critique of the Application presentation

5.2 STEP 1: CHARACTERIZATION OF SURFACE WATER RESOURCES

A general description of surface water resources is presented in Section 3.3.2 of the Application. Additional relevant information is presented in other portions of Section 3.3; Section 3.3.3 (Runoff and Absorption), Section 3.3.4 (Floods and Floodplains), and Section 3.3.6 (Public Water Supplies). Relevant information concerning the characteristics of surface water, particularly as they apply to stream crossings, are Section 3.1 (Earth) and Section 3.4 (Plants and Animals).

5.2.1 CRITIQUE OF SURFACE WATER CHARACTERIZATION

In general, the Application does a fairly good job in describing basic surface water parameters at stream crossings. However, the description is incomplete. Consequently, the stream crossing sensitivity index is based on incomplete information. For example, stream characteristics are only defined for stream crossing locations. Channel gradients upstream and downstream are not typically defined. Habitat downstream or upstream of crossings is also typically not discussed. Another example is the presence of shallow bedrock. This is an important parameter for identifying construction related practices; however, the stream crossing presentation does not identify this characteristic at specific crossings. An additional critique of the surface water characterization is presented in other sections of this chapter and other chapters in this report. Additional critique is also presented by the Tulalip Tribes in their discussion on west side fishery issues and Council for the Environment on their discussion on east side fishery issues.

5.3 STEP 2: IDENTIFY REGULATORY RESTRICTIONS AND REQUIREMENTS

Construction and operation of the pipeline must comply with existing environmental and water supply regulations. These regulations should be a benchmark for evaluating the likely effectiveness of mitigation measures. The scope of appropriate regulations are not identified in the Application, especially as they pertain to local or small water systems and cleanup or compliance standards. A critique of the discussion of applicable and appropriate regulations is presented in the Aquifer Impacts chapter and other sections of this chapter.

5.4 STEP 3: IDENTIFY SURFACE WATER USES

A description of surface water uses is the basis for describing the sensitivity of surface water resources. Surface water uses include consumptive and non-consumptive human uses as well as environmental uses. The Application presentation on human uses is incomplete and too general to adequately describe surface water sensitivity. A description and critique on the Application presentation is presented in the Aquifer Impacts chapter of this report. Similarly, the Application presentation on environmental surface water uses is incomplete. This is especially true in the description of fisheries resources at individual streams as well as the value of these individual resources for the health of the basin fisheries. A discussion and critique of environmental uses is presented in other sections of this chapter and in documents presented by the Tulalip Tribes and the Council for the Environment.

5.5 STEP 4: DEVELOP A SENSITIVITY RATING SCHEME

The Application presents a sensitivity index for surface water at stream crossings. The index focuses on stream crossings because Aconstruction and operation (impacts) will largely be observed at stream crossings and downstream of stream crossings@ (p. 3.3-32). The Application states that the sensitivity can largely be assessed as a function of stream channel and aquatic habitat conditions.

The index rates the sensitivity of streams based on bankfull channel width, channel gradient, and bed and bank erodibility (p.3.3-33). It also considers the DNR stream type rating as a factor of sensitivity. A description of each parameter (or factor) is presented in Table 3.3-5.

Bankfull channel width appears to essentially relate to the size of the stream. Large streams have large bankfull widths and are given a high sensitivity rating of 3; similarly, small streams typically have a low rating of 1. Channel gradient conditions range from shallow gradient streams with a slope less than 2 % to steep gradient streams with a slope greater than 4 %. Shallow gradient streams are given a low sensitivity rating of 1. The steepest streams are given a rating of 3. Erodibility corresponds to the substrate of the stream. Sand and silt substrates are considered more easily eroded and given a high sensitivity rating of 3. Gravel and cobble substrates are given a low rating of 1. Examples of erodibility include the Snoqualmie River, which is given an erodibility index of 3, while the Tolt has an erodibility index of 2.

DNR stream type ratings are apparently included to represent stream environmental sensitivity. The DNR classifies streams from 1 to 5 based on various characteristics. These ratings have been compressed in the sensitivity index to span a range from 1 to 3. The highest quality streams (Type 1 and 2) are given sensitivity ratings of 3.

The above-mentioned four parameters are combined to give a hydrologic sensitivity rating. The five crossings of the Snoqualmie score the highest ratings of 10 or 11. The only other stream with a similar rating is Little Creek in the upper Yakima basin. The Tolt river main channel has a rating of 9, the side channel has a rating of 7. Griffin Creek has a rating of 7, lower than a number of unnamed creeks.

The Application states that the most sensitive stream crossings are Athose with ratings greater than one standard deviation above the mean for all crossings@ or 41 crossings (p. 3.3-45). The Application does not say what the statistical mean crossing is or what one standard deviation represents.

5.5.1 CRITIQUE OF SENSITIVITY RATING SCHEME

The sensitivity index is insufficient on at least three accounts. First, the scope of the index is too narrow. Stream crossings are important, but so is the river downgradient. Second, the approach to calculating the index appears to lack a strong technical basis. Third, the use or application of the index is not clear.

5.5.1.1 Scope

The index is a calculation of the sensitivity of a stream crossing. While the sensitivity of a stream at the crossing may be most dependent on characteristics of the stream at the crossing, this is less likely to be the case for operation impacts. Yet the index is supposed to apply to both. The rate of migration of a spill and the mortality of fish and wildlife will be dependent on downstream characteristics. As demonstrated in the product spill analyses, the spill will rapidly migrate downstream and likely affect a large area. The sensitivity of the stream at the crossing will not reveal much about the downstream population of either migrating Chinook salmon, or the amount of optimal spawning and rearing habitat that could be affected. Also, a classification scheme was already developed in Section 3.4 based on fish utilization at stream crossings (Table 3.4-8). However, this classification scheme is completely ignored in the development of an impact sensitivity rating scheme for stream crossings in Section 3.2. These two rating schemes must be integrated and reconciled prior to identifying likely impacts and appropriate mitigation measures.

5.5.1.2 Parameter Selection

The selection and application of parameters appears to be arbitrary and does not adequately reflect the sensitivity of the environment. In the Application rating scheme, water use is summarized in a single DNR parameter for stream type. The DNR stream designation (WAC 222-16-030) is a general indication of stream value, but does not adequately account for specific existing surface water uses. The relative importance of a stream for salmon spawning is not taken into account. For example, Griffin Creek has a coho salmon escapement between 29% and 49% of the entire Snoqualmie Basin (see technical comments by the Tulalip Tribes). This stream, however, has the same DNR stream type rating as Boxely Creek (Application stream crossing # 44). Boxely Creek is above Snoqualmie Falls and has no anadromous fishery. This example illustrates how the DNR rating is not adequate for identifying specific fish populations and, consequently, sensitive fish populations. In addition, the DNR rating has been found to greatly underestimate the occurrence of fish-bearing streams and fish use in the Snoqualmie basin and other areas of Washington State (see technical comments by the Tulalip Tribes).

The proximity of a municipal supply intake is also not reflected. The DNR parameter designation should be replaced by a set of more specific water use parameters.

The index does not take into account slope stability. Slope stability at stream crossings should be defined and entered in the index. Unstable slopes represent a higher risk of an impact that is not reflected in the index.

The erodibility index parameter is based on substrate. Fine substrates are more highly erodible according to the Application. However, coarse substrates are indications of higher energy environments that may be more susceptible to erosion. Also, it is not clear what is meant by Asubstrate.@ It could be the underlying bed material or the native soil beneath the scour zone. In summary, the representativeness of this parameter needs to be justified by additional technical discussion and reference.

The importance of using bankfull width as a separate parameter is not discussed in the Application. Bankfull width may be an important general stream classification parameter. However, its use as a separate classification parameter for impact sensitivity overweighs its likely importance. For example, larger streams are given the highest sensitivity. However, these streams, such as the Snoqualmie, would likely be able to absorb a small spill or construction impact without appreciable environmental damage. A smaller stream such as Griffin Creek that has spawning gravel present could be significantly effected. A similar type of impact would apply in the case of operation impacts. Bankfull width should be combined with other parameters such as flood prone width, channel depth and substrate to get a parameter that relates specifically to scour potential or channel migration potential.

The index also does not reflect stream or river basin characteristics. Small basins are more susceptible to flooding resulting from development (e.g. urbanization or logging) (Leopold 1994).

Consequently, basin size will affect the potential for impact scour and channel migration risk. A discussion of basin size should be part of the impact sensitivity evaluation.

5.5.1.3 Methodology

The development and application of the sensitivity index appears to lack any technical documentation or reference. Technical sources on resource valuation, erodibility and scour should be referenced. Currently, the lack of documentation contributes to the lack of credibility of this section. There are accepted classification schemes available that present technically defensible methodologies for stream channel classification which are not discussed or referenced in the text. For example, the Rosgen system of channel classification presents a classification scheme based on ratios of bankfull width, floodprone width, and bankfull depth. This scheme also takes into account substrate type (Leopold 1994).

An impact sensitivity index should be developed for both construction and operation impacts. The construction index should consist of the following separate parameters:

Use Parameters:

Environmental quality at the crossing (existing and potential fish and wildlife use, pristine condition, spawning habitat etc.)

Human uses at the crossing (recreation, water supply etc.).

Susceptibility Parameters:

Erodibility at the crossing

Construction feasibility (steep banks, crossing width, channel gradient etc).

Use parameters should be given a weight equal to or greater than the susceptibility parameters. This weighting preference reflects what should be the ultimate objective of the rating scheme; to protect stream uses. The definition of crossing should be defined for the construction index to include a specified distance downstream. The distance should be set based on the likelihood of turbidity from construction effecting instream uses. This distance should be set with reference to the scientific literature or evaluated through modeling.

The operation impacts index should include the same use parameters. Susceptibility parameters should be based on factors that are like to cause a pipeline leak or spill or are likely to increase the impact of a leak or spill. Operation index parameters should include:

Use Parameters:

Environmental quality downstream of the crossing

Human uses downstream of the crossing.

Susceptibility Parameters:

Scour potential

Lateral migration potential

Geohazard potential

Corrosion potential

Stream flow.

The definition of downstream should be developed by analysis presented in the Application with reference to the scientific literature and case studies. Similar to the construction impacts index, use parameters should be weighted at least as heavily as susceptibility parameters.

Once the index is calculated, it should be the basis for specifying construction and operation mitigation. The determination of a threshold value, the value where additional mitigation measures are necessary, should be discussed thoroughly in the Application. Currently, the Application specifies a threshold value of one standard deviation above the mean of all rated streams. There is no justification for this number. If the index values were normally distributed, one standard deviation above the mean would represent about the 84th percentile. This approach is simply a numbers game and does not relate to the susceptibility of the site or the use of the site. Even in the Application, there is confusion on the arbitrarily specified threshold value. The Application states that the Amost sensitive@ stream crossings are greater than one standard deviation above the mean; these stream crossings will have more Afrequent and focused@ monitoring (p. 3.3-45). The very next paragraph in the text defines the Amost sensitive@ stream crossings as being two standard deviations above the mean. These other most sensitive stream crossings will have developed design plans and drawings.

The lack of appropriate methodology incorporated in the current sensitivity index is reflected in the results. Griffin Creek, which according to the Tulalip Tribes is one of the most important salmon spawning streams in the Snoqualmie Valley, has a sensitivity rating of only seven, close to the minimum rating of six given to any stream west of the Cascade crest.

5.5.1.4 Application

Clear objectives for the sensitivity index are not presented in the Application. Consequently, it is not clear if the index is supposed to represent a tool for developing mitigation, to determine a design safety factor, to estimate additional construction costs, or a whether it is simply a general representation of risk. Supposedly, the index was developed to determine mitigation measures, but the Application makes a reference to the sensitivity index only twice in discussing surface water mitigation. These references are mentioned above for the Amost sensitive@ stream crossing. However, in general, mitigation measures consist of BMPs that will, in most cases, be employed at all stream crossings. These BMPs are essentially standard construction practices that do not take into account sensitive resources (such as endangered species) or locations that represent a high risk for a significant impact. The Application also makes reference to Asensitive fish habitat@ (p. 3.3-46). It is not clear if this reference refers to a separate sensitivity index or is a general qualitative statement. It is clear, that there is not an objective and defensible methodology for the application of surface water mitigation measures along the pipeline route.

5.6 STEP 5: IDENTIFY CONSTRUCTION, REPAIR AND ABANDONMENT IMPACTS AND MITIGATION

In Section 3.2.2, the Application presents an impact assessment to surface water. The focus of the assessment is Aon the stream crossings and on the banks and approach slopes to stream crossings@ (p. 3.3-27). The rationale for this focus is that Apipeline stream crossings are the most critical and sensitive to impacts@ (p. 3.3-27). The assessment is organized into three sections: construction-related impacts (p. 3.3-27), operation-related impacts, and impact sensitivity. The general types of construction and operation impacts defined in the Application (p. 3.3-26) are:

Channel and bank disturbance with subsequent habitat loss

Erosion and sedimentation with subsequent impact to water quality and habitat

Flow interruptions through emplacement of improper drainage structures

Pipe exposures from scour

Localized water quality degradation from construction

Possible leaks and spills from operation.

The Application maintains the Aprimary (construction) impact will be effects of increased erosion and sedimentation@ (p. 3.3-28). As stated in the Application, A the presence of suspended sediment in the water columnY. can be injurious to aquatic life@ (p. 3.3-28). The surface water bodies most vulnerable to construction impacts Ainclude steep channels with banks and beds composed of erodible unconsolidated sediments@ (p. 3.3-30).

Erosion and sedimentation will result from emplacement of the CCP across the stream. There are nine crossing methods (p. 2.14-5). Four of these methods are defined in the draft EIS (Jones and Stokes 1998, p. 3-125) as Ainvasive methods.@ Invasive methods defined in the DEIS in order of decreasing impact intensity are dry trench, flume and trench, divert and trench, and wet trench. Non-invasive methods defined in the DEIS are bridge, bore, horizontal directional drill, over culvert and under culvert. Open cut methods (which fall under the draft EIS definition of invasive) are used Amost often to bury the pipeline@ (p. 3.3-28). Though not explicitly stated in Section 3.3.2.2 or Section 2.14, it is implied in the Application that the wet trenching open cut method would have the highest erosion and sedimentation impact. This method would be used only for Alow sensitivity and/or low velocity@ streams. This determination would be made by the Aconstruction manager Y at the time of construction@ (p. 3.3-28). Based on the Application, the sensitivity index would be updated by this field assessment and previously collected design information. The determination would then be made to use wet trenching Aor the alternate dry trenching method@ (p. 3.3-28), which the DEIS states is less invasive.

The Application discusses a modified open cut method that uses a diversion flume (a.k.a. flume and trench). The criteria for using this method are Asmall watercourses with defined banks, defined channels and a solid fine textured substrate@ as well as A when sedimentation and fish passage are a concern@ (p. 3.3-29). When streams are too large to flume, the diversion method (a.k.a. divert and trench) is proposed as an alternative to the diversion flume. Apparently, this method requires diverting the stream away from the construction area.

Directional drilling and bridge crossing are the two other stream crossing methods that are discussed. Directional drilling Ais employed where excavation methods are impractical@ (p. 3.3-29). The Application gives examples of types of impractical situations. These situations are shallow bedrock, the stream is too large for trenching, and bank and bed instability is present (p. 3.3-29). Bridge crossings will be used when an appropriate bridge exists. Directional drilling and bridge crossings are characterized as having Aless potential impact.@ They are considered Anon-invasive@ methods in the draft EIS (Jones and Stokes 1998).

Other construction impacts that are mentioned include removal of riparian vegetation and toxic impacts of incidental petroleum spills (from refueling track hoes, and trucks etc), and blasting. Removal of riparian vegetation could increase stream temperatures and effect fish survival rates (p. 3.3-31) as well as increase erosion. Accidental petroleum spills Acould affect aquatic organisms@ through toxicity or coating of surface sediments (p. 3.3-30). Blasting could kill or harm fish through acoustic shock. According to the Application, no blasting is planned.

5.6.1 CRITIQUE OF CONSTRUCTION, REPAIR AND ABANDONMENT IMPACTS

The discussion of construction impacts is insufficient on at least two significant accounts. First, it lacks specificity. Descriptions are general and vague. The result is that the magnitude of construction impacts or not defined, and it is not clear who or what will be affected. In fact, as noted above, the proposed construction methods are often in doubt. Second, the description has a number of inconsistencies with other information in the Application or other scientific or engineering information. This makes the document difficult to review and calls into questions the reliability of the conclusions that are made.

5.6.1.1 Relative Crossing Method Evaluation

The Application description of crossing methods is too general and vague. There does not appear to be any specific discussion on the relative impact of each method. In contrast to the DEIS, the Application does not rank methods by the degree of impacts. Each crossing method could be characterized by impact potential (i.e., erosion potential, impact on bank stability, optimal geologic and morphologic conditions, etc.). The ranking or description could then be compared to site-specific physical conditions and sensitivity index to minimize impact and maximize constructability. The qualitative discussion concerning wet trenching does not provide a sufficient basis to incorporate construction methodology into a decision process. For example, the criteria for using modified open cut methods are where fish passage is a concern. This condition applies to essentially all the crossings west of the Columbia.

5.6.1.2 Quantification of Impact

The Application admits that construction can impact the environment and cause fish stress and mortality. The discussion, however, is cursory and does not provide an estimate of the degree of impact. There is no discussion on the amount of sediment that may be generated for each of the different Ainvasive@ methods. One of the few conditional factors discussed for Ainvasive@ methods is the appropriate use of wet trenching for low velocity streams. Yet a low velocity stream is not defined or put into context. If it discussed elsewhere in the Application, that discussion is not referenced.

Fish mortality, stress and avoidance may be difficult to calculate. However, stream crossing case studies that evaluated fish impacts would provide an approximate procedure for quantifying impacts. Another source of information may be instream experiments that evaluated the effect of varying turbidity levels on fish. The availability of this information and its use in evaluating construction impacts should be discussed.

As stated in the Application, a construction related petroleum spill could cause fish mortality. However, there is no discussion on either the size of a spill that is a concern, the anticipated environmental impacts, or the toxic threshold effects of petroleum on fish. In summary, the Application does not present sufficient information for a reviewer to reasonably estimate the degree of environmental impact caused by a construction related petroleum spill.

From a regulatory perspective, it is necessary to predict the extent or length of an impact from construction. For example, the state surface water quality regulations (WAC 173-201A-070) has an antidegradation provision that prohibits actions that are detrimental to a stream=s beneficial use (p. 3.3-8). A short term modification (STM) is allowed (WAC 173-201A-110), however, with certain limitations. STMs must not result in long term harm to the environment. Also, the project must meet turbidity criteria at a point of compliance [WAC 173-201A-110 (3)]. For a stream flowing at 10 cubic feet per second (cfs) at the time of construction the point of compliance is 100 ft downstream. Based on the Application, it is not clear that the project recognizes or is capable of complying with the state surface water quality regulations. These regulations should be defined and used as a benchmark to evaluate the need for alternative construction methods and mitigation.

5.6.1.3 Directional Drilling versus Blasting

The Application mentions the use of blasting, but does not mention under what conditions blasting would be necessary. Though not specified in the Application, blasting would presumably be necessary if shallow bedrock is encountered during trenching operation. The Application, however, specifically indicates that directional drilling will be appropriate where shallow bedrock is encountered. There is presumably a large difference between the impact of directional drilling versus blasting yet there is no information concerning the criteria of use for these two vastly different methods. Also, the Application should be able to present sufficient detail to provide a reasonably accurate estimate of the number of times shallow bedrock will be encountered. This deficiency obviously relates to the overly general discussion of geology and geomorphology. This is the type of information that is crucial for estimating project environmental impacts in general and the degree of fish mortality that can be expected by the project. As the project is currently described in the Application, blasting could be used frequently and at locations where highly sensitive and fragile fisheries resources exist.

5.6.1.4 Completeness

The discussion of crossing methods is not complete. Only six of the nine methods listed in Section 2.14 are discussed under construction impacts. Under culvert, over culvert, and jack and bore are not discussed at all under Construction Impacts in Section 3.2. These methods will have construction impacts. Presumably they will be used mostly at irrigation canals, but this intent is not stated. Presumably, these methods have the potential to impact the integrity of the canal. Also, jack and bore requires dewatering if the water table is near the surface. Given the lack of specificity of the depth to water characterization in Section 3.3-5 it is not clear if jack and bore will be feasible where it is proposed in Table 3.3-6.

The Application mentions that flow interruptions due the emplacement of improper drainage structures is a construction (or operation) impact. This passing reference to culverts is insufficient. The applicant must take the issue of culverts seriously, and spend the resources to properly design and maintain these structures. Culvert sizing is extremely important because restrictive culverts can back up flow leading to catastrophic failure. Where the CCP crosses existing streams with culverts, the culverts need to be evaluated and replaced if they do not meet design criteria. This evaluation has to occur not only at the crossing, but also upstream of the crossing as well. The size of the culvert should be based on a storm event return period that takes into account the design life of the pipeline. To our knowledge, OPL has not specified a design life for the CCP. OPL=s intent with respect to design life is a prerequisite for preliminary design and cost estimation.

To function properly culverts must be sized properly, but also must be maintained. Clogged culverts can back up flow and lead to catastrophic failure. Maintenance of culverts is not mentioned under construction impacts. To provide an adequate level of safety, the CCP should identify and evaluate all culverts upstream of stream crossings. Culverts that do not meet specific criteria based on the pipeline design life should be upgraded. All upstream culverts should be part of a regular maintenance schedule. Culvert evaluation and maintenance could be a significant pipeline cost; however, it is not possible to determine the scope of this effort from the Application.

5.6.1.5 Consistency

The Application indicates that directional drilling is appropriate for conditions where bank and bed stability is an issue. However, this method is only proposed at one location, the Columbia River Crossing (Table 3.3-6). There are a number of areas (defined in the Application) where slope stability is a concern at stream crossings (e.g. the Griffin Creek crossing). These areas are not identified and evaluated for appropriate crossing method in the Application. The document leaves this analysis up to the reviewer. Evaluation and selection of appropriate crossing method should be presented in the Application.

5.6.1.6 Abandonment and Repair

The Application does not discuss the impacts of CCP decommissioning or repair. Presumably, the CCP has a finite useful life either due to wear or obsolescence. Consequently, the CCP will have to be abandoned. The need for abandonment or the methods that would be considered are not mentioned in the Application. Consequently, the environmental impact of the project is not fully characterized.

Repair of the pipeline is a significant issue. If a leak occurs at a stream crossing, construction activities will likely be necessary within the streambed regardless of the presence of migrating salmon, creek flow etc. In some cases, such as beneath the Columbia River it is likely that repair will not be feasible and a new pipeline will have to be installed. The impacts of repair at stream crossings both on the environment and the reliability of supply are not discussed in the Application.

5.7 STEP 6: IDENTIFY OPERATION IMPACTS AND MITIGATION

The Application presents a one-page discussion of operation impacts. These impacts are summarized as ongoing construction related impacts, slope erosion, and instability due to poor trench drainage, and pipeline leaks or spills. The Application mentions that scour can cause a leak and that the leak can impact Asenior water rights.@ Storm water runoff impacts at the Kittitas terminal are also mentioned. Though not referenced in the Application, product spill analyses are presented in Appendix B-2 of the Application. These analyses describe various reasonable or likely scenarios where spills to surface water will affect fisheries and aquatic resources, wetlands, recreation, and Sand Hill Cranes. In these analyses, the causes of failure are corrosion, external impact, weld failure, and slope failure (see Application Appendix B-2, Table A-1)

5.7.1 CRITIQUE OF OPERATION IMPACTS AND MITIGATION

The discussion of operational impacts is superficial and incomplete. There is neither a review of the causes of impacts, the likelihood of an impact, or the characteristics of an impact. Consequently, there is not enough information in this section to seriously evaluate operational impacts. As demonstrated in Section 2.9, Spill Prevention and Control, leaks and spills of the pipeline will occur. A reading of this section should provide the reviewer with a sense of the extent of these impacts and whether route conditions make a leak or spill more or less likely than typical pipeline conditions or conditions that exist associated with OPL=s north-south pipeline.

5.7.1.1 Leak or Spill Processes

The Application only mentions a single spill hazard - scour - in this section. Other areas of the Application and the draft EIS mention other spill hazards specifically associated with stream crossings. These hazards include increased corrosion (where the pipe is buried), slope stability, lateral channel migration, and liquefaction. The lack of consistency calls into question the basis for recommendations presented in the Application.

The Application should identify each specific spill hazard that is likely to result in a pipeline spill or leak. Each of these hazards should be ranked based on the likelihood that they will cause a product release. The ranking should be consistent with technical and engineering literature on pipeline crossings. Once each spill hazard is ranked, each crossing should be evaluated to determine the potential susceptibility to each spill hazard. This ranking should serve as a prerequisite for mitigation.

5.7.1.2 Spill Impact: General Regulatory and Technical Considerations

The effect of a spill on the environment is not discussed from either a regulatory basis or a scientific basis. A reading of the Application leaves a reviewer unsure of how the environment will be impacted from a spill and what regulatory safeguards exist to protect the environment. A clear and defensible presentation of the effect of a spill on the environment must be presented in the Application. Additionally, the regulatory context under which OPL will be required to respond should be clearly presented. The product spill analyses (that are not even referenced in Section 3.2) do present a qualitative spill assessment under a variety of conditions. These spill assessments are themselves incomplete and undocumented.

The impact of a product leak or spill will be highly variable based on a number of factors related to the spill characteristics, the physical environment and the type of receptors present. To understand and have confidence in a spill or leak impact analysis, each of these factors should be discussed and integrated. The Application simply does not provide this minimum level of analysis. Information that should be included in the Application is discussed below.

A number of processes will impact a release of product into surface water. Mixing, vertical dispersion, and evaporation should be discussed and quantified. These variables should be put into context and should be used as the basis for selecting appropriate product spill analyses. The impact of stream velocity, gradient, volume, and ambient temperature on the persistence and migration of a spill should also be discussed. Persistence and migration of petroleum will also be impacted by the properties of the product. For example, the spreading ability of product on surface water will be a function of viscosity, specific gravity, and surface tension. Consequently, regular gasoline, super gasoline, jet fuel, and diesel will all behave differently. Currently, the Application does not discuss or apparently contemplate the different environmental fate, transport, or toxicity of the different products.

A spill to surface water will be subject to federal and state cleanup requirements. These requirements include federal freshwater acute and chronic toxicity based regulatory criteria [40 CFR 131.36(b)(1)], the state surface water quality regulations (WAC 173-201A-040), MTCA (WAC 173-340-730), and federal criteria for consumption of water and organisms [40 CFR 131.36(b)(1)]. The federal regulations are promulgated pursuant to the Clean Water Act. It is not clear if the CCP intends to comply with these state and federal regulations or even considers all of them applicable. For example, the most stringent benzene criteria under these regulations are 1.2 ug/l (based on federal criteria for human consumption of water and organisms). Regular gasoline in contact with surface water can result in dissolved concentrations up to approximately 30 mg/l (API 1989). Super-unleaded gasoline can result in significantly higher concentrations.

The issue of methyl tertiary-butyl ether (MTBE) is also not discussed. Even if MTBE is not currently added to the fuel mix, it could be added in the future. It typically makes up about 10 percent of gasoline by volume (Andrews 1998) and has a higher solubility then most common gasoline constituents. MTBE has recently been recognized as a long-term threat to water resources

(Andrews 1998). The EPA established a drinking water health advisory of 20 to 40 ug/l based on taste and odor considerations and has concluded that these levels should be protective of toxic effects. A Method A cleanup level for MTBE of 20 ug/l is proposed in the revised MTCA regulations. MTBE is significant because it is more mobile and persistent then most common refined product constituents. For example, MTBE in super unleaded gasoline is estimated to have a maximum solubility of over 900,000 ug/l (API 1989). By contrast, the maximum benzene solubility would be less than 70,000 ug/l. The potential presence of MTBE in OPL product that will be transported on the CCP needs to be discussed in the context of human health and environmental impacts from a spill.

The product spill analyses assume simply that gasoline is more acutely toxic to living organisms then diesel. This is an overly simplistic evaluation. For example, diesel, because of its higher viscosity lower solubility and lower vapor pressure, will be more persistent. If a diesel spill impacts the hyporheic zone or the shoreline, it is likely to persist for a longer period of time, likely affecting salmon spawning and rearing capability even if it does not produce dissolved concentrations that are acutely toxic to adult fish. The product spill analysis presents a general reference of the toxicity of petroleum on fish published by the American Petroleum Institute. There are no specific quantitative references to this document, and the document is not mentioned in Section 3.2 of the text.

There is also a concern that concentrations of petroleum in surface water even lower than chronic concentrations can cause fish to avoid their normal habitat, spawning grounds and migratory routes. The issue of environmental cleanup standards for surface water is not addressed at all in the Application. Cleanup standards are important to evaluate estimated potential impacts. For example, even if the Application did estimate a surface water concentration from a spill, the impact on fish and other aquatic and terrestrial organisms could not be estimated. From a regulatory perspective, MTCA requires all cleanups to be protective of both human health and the environment. Human health cleanup standards are presented in these regulations, but environmental standards are not. State surface water quality regulations (WAC 173-201A-040) state that Atoxic substances shall not be introduced above natural background levels Y which have the potentialY. to adversely effectY the most sensitive biota.@ Federal clean water act and companion surface water quality regulations do present freshwater acute and chronic toxicity values (WAC 173-201A-040); however, no values have yet been promulgated for petroleum constituents. The Application does state that product is toxic to aquatic life, yet without providing any indication on how toxic. The Application should identify standards the CCP will be required to meet. These standards should either be based on applicable and appropriate regulations, literature data, and/or case studies associated with actual spills. The expressed purpose of this evaluation should be twofold: to estimate a fish kill or other toxic impact associated with a spill, and to set cleanup levels for both soil and surface water.

5.7.1.3 Spill Impact: Volume

Spill volume is an essential part of estimating the impact of a spill or leak. Historic releases are presented in Section 2.9. Product spill analyses supposedly Arepresent the practical worst case discharge volumes@ (Appendix B-2 p. 14) for a release. In the product spill analyses, the maximum discharge for a slow leak is about 13,000 gallons (Appendix B-2, Table 4-1). This value is not a credible worst case discharge. It assumes that the leak will in all cases be detected within 72 hours. Also, the volume does not ever approach the volume of actual leaks that have occurred on Olympic=s north-south pipeline. The Renton leak in 1986, which occurred in a populated area, spilled between 80,000 and 320,000 gallons depending if you use Olympic=s estimate or the City of Renton=s estimate. These estimates do not even take into account the unpredicted reoccurrence of the groundwater plume and free product in 1998. Given the accessibility of this area, the Renton spill should be used as the lower bound for a product spill analysis.

The maximum spill volume used in any of the rupture/spill scenarios is 162,100 gallons on Snoqualmie Pass near Hyak. Based simply on spill history, this volume is not a credible practical worst case spill volume for use in a scenario. The existing OPL north-south pipeline experienced a mainline rupture at the Allen Station, which was approximately 168,000 gallons (Table 2.9-1). A Colonial Pipeline spill in Reston, VA in March 28th, 1993 was 408,000 gallons. This spill was into Sugerland Run and subsequently into the Potomac River (U.S. Department of Interior et.al. 1998). Olympic=s failure to use credible spill volume numbers for leaks or spills calls into question their entire spill volume analyses.

5.7.1.4 Spill Impact Evaluation: Modeling

A spill or leak impact on surface water is difficult to predict. For initial screening and as a check on more thorough analyses, simple dilution models will give a good indication of contaminant levels for conditions with low volatility, low biodegradation, and low adsorption. A more thorough approach to evaluating a product release impact is to develop a model that is capable of taking into account the appropriate physical, biological, and chemical parameters. The advantage of a modeling approach is that once the model is constructed, it is typically an efficient tool to perform a sensitivity analysis associated with various impact parameters. Impact parameters (such as air temperature or stream gradient) can be varied within an expected range to determine the resultant range in likely dissolved petroleum constituent concentrations. Modeling in conjunction with toxicity data, can be used to identify a combination of factors that are likely to produce significant impacts to human health and environmental uses.

The National Oceanic and Atmospheric Administration (NOAA) presents a discussion of oil spill modeling on inland waters (Overstreet and Galt 1995). A number of surface water quality models are available from either the USGS or EPA that would provide screening level information on exposure point concentrations in surface water under a number of spill scenarios. Two potentially appropriate models may be SMPTOX (http://www.epa.gov/epa_ceam/ wwwhtml/smptox3.htm) or WASP (http://www.epa.gov/epa_ceam/wwwhtml/wasp.htm) (Pelletier 1998). SMPTOX stands for

Simplified Method Program Variable Complexity Stream Toxics Model. The model is personal computer based and provides a steady state concentration for dissolved phase, suspended sediments, and bed load sediment from point source discharge into a stream. WASP or the Water Quality Analysis Simulation Program is a general framework model for modeling contaminant fate and transport in surface water. The model can simulate dynamic concentrations of organic chemicals in one, two and three dimensions.

The above-mentioned surface water quality modeling programs are appropriate tools that should be used in the context of product spill analyses. Analytical or numerical modeling represents a relatively efficient approach to analyzing the multiple parameters associated with a spill. These parameters include loading or source terms, transport terms, and reaction terms (Chapra 1997). Loading terms are associated with the source of a spill such as the mass or volume of spill over time. Transport terms are a function of physical stream flow processes and include dispersion and diffusion. Reaction terms represent loss of the substance due to partitioning (i.e. adsorption or volatilization) or degradation. The Application needs to present a discussion of all these parameters and evaluate their importance in the context of a spill. The result of this evaluation should be Aa reasonable worst case@ exposure concentration for environmental and human health receptors. Modeling is an efficient approach to performing this evaluation.

5.7.1.5 Spill Impact Response

Surface water characteristics are going to impact the ability of OPL to effectively respond to a spill. On high gradient streams, boom effectiveness will tend to be limited. The product spill analyses suggest that booms will be effective in protecting sensitive receptors and populations. In many locations and weather conditions booms are unlikely to be effective. Information on surface water conditions relative to boom placement need to be described to evaluate the reasonableness of the product spill analyses. As an example, Shell Oil experienced a spill of 20,500 barrels into a small river in Missouri in 1992. Multiple parallel booms were applied at four locations (40,000 ft of booms) by the emergency response team. Still, enough floating oil jumped the booms to cause a sheen 100 miles downstream on the Mississippi River in St. Louis and require contingency actions by municipal suppliers. Forty vacuum trucks and 40 transport trucks were involved in hauling oil from the boom sites. Shell concluded that boom technology was not sufficient to contain product in many river situations and the amount of oil that could be trapped is limited by the availability of vacuum and transport trucks.

The severity of a leak or spill will be based on the ability of OPL to detect and respond. Neither the main text nor the product spill analyses address logistical constraints in a comprehensive manner. Response to a spill is likely to be much more difficult then the current OPL north-south pipeline due to a number of factors. These factors include remoteness of the proposed route, the inaccessibility of the route, the mountainous terrain, snow and poor mountain weather conditions. Booming and containing a spill will also be much more difficult simply due to stream gradients. The segment of the CCP through the Cascades will have substantially higher stream gradients then the current OPL north-south pipeline. With proper consideration of logistical constraints to spill response, the

Application would predict a higher impact on human health and the environment then is currently presented.

In the product spill analyses, much of the oil along the banks and stream shore is left to biodegrade or volatilize. Supporting information is not presented in the Application to support the implication that this approach will not cause significant long-term impacts. Necessary information should be provided on the toxic, chemical and physical properties of the different products and their current or potential additives. If water levels are fluctuating significantly, product will be smeared over a broad band of the shoreline. If water levels are rising, a portion of the product will be trapped below the water surface contributing to a long-term source of dissolved phase product to the surface water body. As stated in the Application, product in the water is toxic to fish (p. 3.3-30). Allowing product to remain and biodegrade along the shoreline could cause continuing toxicity to fish over a long period of time. The presentation of a natural attenuation approach to spill cleanup in the product spill analysis suggests OPL plans on using this low dollar cost response. Natural attenuation may be appropriate if the environmental impacts are low. However, the Application does not present any analysis on toxic or nuisance impacts of leaving residual petroleum in the environment. These impacts are likely to be substantial in some cases. Based on the Application, it sounds like OPL plans on developing information on fish and wildlife mortality when the pipeline leaks.

1.0

6.0 COLUMBIA RIVER CROSSING

6.1 INTRODUCTION

Crossing the Columbia River is technically one of the most challenging parts of the entire proposed Cross Cascade Pipeline Project. Construction challenges center on the suitability of the various crossing alternatives for pipeline installation, including environmental sensitivity, constructability, and mitigation alternatives. Once in place, fuel spills at the crossing sites can potentially impact downstream human and environmental health. Clean up in the event of a leak will be costly, and any necessary repairs have the potential to interrupt fuel supplies for extended periods of time.

The purpose of this chapter is to: 1) briefly summarize Olympic Pipeline Company (OPL) conclusions about proposed crossing alternatives as described in the EFSEC permit Application, 2) our conclusions concerning the material presented in the Application and supporting documents, and 3) summarize recommended actions for improved characterization, environmental protection, impacts mitigation, and construction. The discussion for the Columbia River crossings are divided into sections centering on:

Alternative route evaluation

The physical setting, including geologic, ground water, surface water, and fisheries conditions

Pipeline construction, repair, replacement, and abandonment issues and impacts

Pipeline operational issues and impacts

The results of our review for the Columbia River crossings are that the material presented in the Application and supporting materials is poorly organized, lacks significant detail, and is missing critical elements necessary for decision makers to reasonably determine environmental impacts, costs, and reliability of the proposed pipeline at Columbia River Crossing sites. Material relevant to describing crossing site physical conditions typically is found scattered throughout the Application and in supporting documents. General conclusions for each section of this chapter include:

Crossing alternatives are not systematically developed and final conclusions are not supported by documented facts

Descriptions of crossing site physical conditions, including geology, ground water, and surface water lack continuity, contain errors, ignore published, publicly available information, and are very generalized

Construction, repair, and replacement discussions are based on potentially erroneous site characterization data, assume optimal conditions based on ideal assumptions, and lack any information on construction, repair, and replacement requirements and options

Operational issues and impacts lack any discussion of catastrophic events leading to rapid leaks into the Columbia River, contain conclusions based primarily on ideal assumptions, and lack a credible assessment of leak impacts, including the impact of a leak or rupture on fuel supplies in eastern Washington.

6.2 ALTERNATIVES EVALUATION

The purpose of this section is to: 1) summarize OPL statements about proposed crossing alternatives and criteria used in evaluating each alternative and 2) review of OPL's evaluation process used in the selection of the preferred crossing alternatives. The basic conclusion of our review is that the Application: 1) fails to present a systematic description of the conditions at each crossing site and 2) does not clearly explain criteria upon which crossing alternatives are judged. Consequently, the Application's conclusion regarding preferred crossing alternatives appear to be made without any clear justification.

6.2.1 SUMMARY OF OPL STATEMENTS

Five alternatives are listed for proposed crossing locations of the Columbia River (see Application Section 2.1). These alternatives (locations shown on Figure 1) are:

Wet trenching (dredging) north of the I-90 Bridge

Installation on the I-90 Bridge

Installation on Wanapum Dam

Horizontal directional drilling (HDD) beneath Columbia River just south of Wanapum Dam

Installation on the Beverly railroad bridge

On Table 9.1-4, 4 of the 5 alternatives are listed as having no environmental impact. The only impact identified by OPL for these options centers on downstream sedimentation and fisheries impacts from wet trenching. The feasibility and cost for each option also is listed on Table 9.1-4. The text accompanying this table suggests the information listed on it is based on constructability criteria described in Section 8.2, geotechnical issues discussed in Chapter 3 of the Application, and supporting documents describing geologic, hydrologic, and habitat conditions.

Additional supporting information relevant to route selection and evaluation center on the following Application conclusions:

The HDD route is favored because "...installed pipeline would have little or no maintenance needs, would have less exposure to weather elements, and would not be subject to potential need to move or replace the pipeline should a bridge structure be in need of repair or replacement." Also, it is stated that geotechnical studies completed for the pipeline project confirm suitable conditions exist at the proposed HDD location (Section 2.1).

The I-90 route has not received approval from Washington Department of Transportation (WDOT).

Burlington Northern-Santa Fe (BNSF) Railroad may reactivate the Beverly Bridge

Permission has not yet been granted by Grant County PUD (GCPUD) for installation on Wanapum Dam

Dredging is undesirable because of sedimentation impacts to downstream uses

Section 9.1 and Table 9.1-4 also lists four additional alternatives that are not discussed in the permit. These alternatives include:

HDD north of the I-90 Bridge

HDD south of the I-90 Bridge and upstream of Wanapum Dam

Dredging south of the I-90 Bridge and upstream of Wanapum Dam

Dredging south of Wanapum Dam

Section 9.1 states OPL's favored option is HDD south of Wanapum Dam.

6.2.2 ERRORS, OMISSIONS, AND RECOMMENDATIONS

Based on the information in the Application, selection of an HDD crossing south of Wanapum Dam appears to be derived from a favorable interpretation of site physical conditions (Sec. 2.4), reduced maintenance requirements for a pipeline installed under the river (Sec. 9.1), and the unavailability of any other crossing option. However, at no point in the Application is a clear discussion of technical merits, tabulation of alternative route pros and cons, or systematic evaluation supportive of the conclusions in Section 9.1 and on Table 9.1-4 presented. In addition, permitting, right-of-way, and easement requirements for the proposed alternatives routes are not discussed.

The Application should be revised or supplemented to include a discussion of the specific permitting, engineering and licensing issues and impacts for each crossing alternative. From this, a concise and technically defensible comparative analyses of each option should be prepared and presented for review. The revision should include a basis for calculating cost estimates.

6.3 SITE CONDITIONS

The purpose of this section is to discuss: 1) Application conclusions relative to conditions at the proposed crossing sites, including geology, groundwater, surface water, and fisheries and 2) our review and recommendations relative to these factors. Mitigation is not addressed in this section.

6.3.1 GEOLOGY

Discussions of Columbia River crossing conditions are scattered throughout the Application and supporting material. Nowhere in the Application is a single section devoted to a comprehensive review of route and crossing geologic conditions. The following discussion reviews OPL statements concerning the proposed crossing and specific issues we have identified with respect to site sedimentary and bedrock geology, faults, and seismicity. The basic conclusions of our review center on the following shortcomings in the Application:

Regional and site specific information relative to crossing geologic conditions is not cited.

Conclusions presented in the Application are not consistent with conclusions from other reports, papers

Investigations and analyses carried out to-date have not adequately assessed site physical conditions.

- X A systematic evaluation of conditions at each crossing is not presented.

X **6.3.1.1 Sedimentary and Basalt Geology**

Throughout the Application the primary geologic units identified at the proposed alternative crossing sites are, from oldest to youngest, Tertiary basalt bedrock (Tb), Quaternary glacial derived sand and gravel (Qfg), and Quaternary alluvial gravel and sand (Qa), or some variation on this terminology. Fill material related to Wanapum Dam construction also is described as being present. The following sections summarize Application conclusions for each of these units and errors and omissions we have identified.

3.1.1.1 Basalt Bedrock (Tb)

Application - The Application acknowledges that basalt bedrock underlies Quaternary and younger sedimentary strata at all of the proposed crossing sites. The Application assumes that basalt bedrock is deep enough at all of the crossing sites that it will not be encountered during pipeline construction. In addition, specifically at the proposed HDD site, Dames and Moore (1998, pg. 8) states that bedrock elevation is at approximately 360 ft above sea level and that this surface is relatively flat across the cross section of the crossing.

Errors and Omissions - The Application contains several errors and omissions related to basalt bedrock. These center on the elevation of basalt bedrock beneath the proposed HDD site and resultant errors in estimates of the thickness of overlying sedimentary strata (e.g., cataclysmic flood deposits). In addition, the presence or absence of basalt bedrock at the proposed wet trenching site is not developed sufficiently to access trenching constraints, requirements, and feasibility.

Previous work at the Wanapum Dam site indicates the basalt surface directly underlying the river channel ranges from approximately 380 feet to 420 feet above sea level (Mackin 1955; Galster 1989) at the proposed HDD location (see Figure 2 for a reconstruction of this interpretation). Lows in the basalt bedrock, down to elevations of 340 feet above sea level, occur beneath both banks (Mackin 1955; Galster 1989). These interpretations are based on borehole drilling done during and following Wanapum Dam construction.

This is a very different picture than what is shown in Dames and Moore (1998, pg. 8, Figs 6, 9, and 14) where the top of basalt bedrock is placed at 345 feet to 370 feet above sea level beneath the river channel. Using Mackin's (1955) bedrock surface map and his borehole logs, as little as 20 feet of bouldery, cataclysmic flood debris potentially lies between the base of the eastern half of the river channel and underlying bedrock in the immediate vicinity of the proposed HDD location. In addition, as described in the previous section, the geologic log Wanapum Dam boring BAK-28 suggests the high probability that the cataclysmic flood deposits overlying this bedrock high are boulder-rich. It may be the abundance of bouldery strata beneath the river that lead to the failure of GPR to identify the bedrock high beneath the channel. Basalt boulders in this deposit may have broken up GPR signals and in effect masked the underlying basalt bedrock surface.

3.1.1.2 Quaternary Fluvial (Glaciofluvial) Gravels

Application - The HDD geotechnical investigation by Dames and Moore (1998) indicates that Quaternary fluvial gravel is the dominant stratigraphic unit above basalt bedrock at the HDD and other alternative crossing sites. This unit is variously described in the Application as:

Water deposited glacial debris (Sec. 2.1.5.1)

Glacial soils left by water from melting glaciers (Sec. 2.14)

Quaternary gravels of the Bretz floods (Sec. 3.1.3.1)

Sand and poorly graded gravel (borehole CC-1)

Poorly graded gravel, sand, and well graded black basalt gravel (borehole CC-2)

An approximately 130 ft thick sequence of sand and gravel underlying the full width of the river (Dames and Moore 1998, pg. 8)

"Grain size curves that include other laboratory results for selected samples..." (Dames and Moore 1998, pg. 8) seems to suggest the maximum grain size of gravel at either end of the proposed HDD crossing is approximately 3 inches. However, later on page 8 and on Figure 7 Dames and Moore (1998) cite ground penetrating radar (GPR) data as indicating the presence of boulders in this unit.

Errors and Omissions - As will be noted with the other sedimentary units, a complete description of the characteristics of this unit also is not presented at any single location in the Application. Site reconnaissance and published geologic literature reveal a number of potential problems with the characterization, description, and interpretation of this stratigraphic unit presented in the Application. Information about the unit, also referred to as Bretz flood deposits, glacial Lake Missoula outburst flood deposits, Missoula flood deposits, Pleistocene cataclysmic flood deposits, Pasco Gravels, and the Hanford formation, that is lacking from the Application is found in Bretz and others (1956), Newcomb and others (1972), Grollier and Bingham (1971 1978), Baker and others (1989), Fecht and others (1987), DOE (1988), Reidel and others (1992), Lindsey and others (1994), and Reidel and Fecht (1994). These papers and reports, in addition to site specific reports on Wanapum Dam (Mackin 1955; Galster 1989), present information about physical properties of cataclysmic flood deposits regionally and locally that do not support the conclusions about the physical characteristics of this unit presented in the Application.

Physical properties typically described for Pleistocene cataclysmic flood deposits and that are supported by site specific reports (Mackin 1955; Galster 1989) and field observations (DBS&A 1998, unpub data) include:

1 to 5 foot diameter basalt and granitic boulders are common in these strata and should be expected in main flood tract channeled scabland settings like the Wanapum Dam site (as well as the other 4 alternative crossing sites). In fact, Wanapum Dam boring BAK-28, which was drilled in mid-channel several hundred feet downstream of the proposed HDD route, describes the presence of boulders in the entire stratigraphic column above basalt (Mackin 1955). Dames and Moore (1998) acknowledges the presence of boulders at the proposed HDD crossing, but seems to downplay their significance.

Clay and silt sized material is largely absent from the matrix of cataclysmic flood gravel, resulting in an openwork or open framework texture typically reported for cataclysmic flood gravels.

Cement is almost completely absent from typical open framework, bouldery cataclysmic flood deposits and clasts are rounded and loose, resulting in extremely unstable and very easily disaggregated gravel deposits.

Rapid lateral pinchouts of both coarse (cobble-boulder) and fine (sand) horizons typically seen in high energy cataclysmic flood deposits (such as those at the crossing sites) make any prediction of suitable subsurface conditions based on the material described in Dames and Moore (1998) problematic at best, and certainly argue against the presence of laterally widespread sand zones such as shown in Dames and Moore (1998, Fig. 14).

Pleistocene cataclysmic floods were truly cataclysmic, and the Application fails to recognize that the truly unique physical events that occurred during these floods resulted in deposition of atypical sediments. This setting, and the deposits formed by it, are significantly different than the conditions and deposits implied by the Application. Conditions and deposits summarized by such Application conclusions as: 1) "Subsurface deposits consist of glacial soils left by water from melting glaciers and recent alluvial soils deposited by the Columbia River." (Pg. 2.14-26), 2) flood waters deposited sand to cobble sized material (Section 3.1.3.1), and 3) the borehole logs and grain size analyses indicate 3 inch diameter gravel is the norm (Dames and Moore 1998). In fact, the inescapable conclusion from published geologic literature is, cataclysmic flood deposits at sites like Wanapum Dam generally contain abundant basalt boulders, in contrast to the conditions portrayed by the Application. In the likelihood that a significant number of boulders are present, material presented in the Application indicates HDD drilling will be very difficult, more so than the Application indicates.

3.1.1.3 Quaternary Alluvium

Application - The Application suggests that Quaternary alluvium consists generally of sand and gravel found on the banks of the Columbia River and on terrace surfaces adjacent to the Columbia River. These strata are interpreted to have been deposited by the Columbia River following the end of Pleistocene cataclysmic flooding.

Errors and Omissions - A complete description of Quaternary alluvium characteristics is not presented at any single location in the Application. Field checks (DBS&A 1998, unpublished data) suggests this stratigraphic unit consists of: 1) a thin veneer of reworked and redeposited cataclysmic flood gravel along the river bank and on undisturbed terrace surfaces and 2) Holocene-aged river deposited sand and gravel generally restricted to swales along the river shore. This is consistent with Quaternary alluvium described and mapped throughout the mid-Columbia region (Baker and others 1989; Reidel and others 1992; Reidel and Fecht 1994). The limited thickness and lateral extent of this material needs to be recognized as having little effect on pipeline construction.

3.1.1.4 Fill Material

Application - By inference, the Application suggests that fill material consists of a range of silt to boulder sized debris. Fill material is described as the material comprising the west bank of the Columbia River at the proposed HDD crossing site where it forms the present constriction in the Columbia River channel just downstream of Wanapum Dam (Dames and Moore 1998). Fill materials are not described or mapped at the other four alternative crossing sites (see route maps).

Errors and Omissions - A complete description of fill material characteristics is not presented at any single location in the Application. In addition, the implication in Dames and Moore (1998) that the west bank of the river below Wanapum Dam is constricted by construction fill material is incorrect. Mapping conducted prior to dam construction (Mackin 1955) and recent field reconnaissance (DBS&A 1998, unpub data) indicates the deposits forming the west bank is largely natural material consisting of Pleistocene cataclysmic (Bretz) flood deposits. However, current position of the west bank reflects excavation done at the time of Wanapum Dam construction and subsequent river erosion. Based on published information and field checks, fill material on the western shore of the river consists of: 1) a thin veneer of sand and gravel overlying the terrace adjacent to the west bank of the river and 2) rip-rap placed along the river bank for erosion control. Significant, mappable amounts of fill are not reported at alternative crossing sites except immediately adjacent to and underlying road grades and various engineered bridge and dam structures. The limited thickness and lateral extent of this material needs to be recognized as having little effect on pipeline construction.

6.3.1.2 Faults, Seismicity, and Mass Wasting

Application - Section 2.15.1.2 of the Application delineates possible hazards that earthquakes pose to the proposed pipeline. Earthquake hazards are subdivided into two categories, fault rupture (ground surface displacement along the fault that could sever the pipeline) and strong ground motion effects (i.e., liquefaction, trigger for landslides). Section 2.15.1.2.1 of the Application concludes that the approach and proposed/alternative routes across the Columbia River (Map Atlas p. 57-66) do not cross any known Quaternary-age faults that could pose a surface-rupture hazard to the pipeline (Table 2.15-1). Sections 2.15.1.2.3 and 2.15.1.7 summarize potential liquefaction and mass wasting (landslides) hazards for the pipeline proposed and alternative routes across the Columbia River. No potential liquefaction hazards were identified for segments of the pipeline route associated with the Columbia River crossing alternatives (Table 2.15-3). A number of landslides were identified (Map Atlas p. 57-66) that the proposed/alternative routes for the pipeline would cross, but all were classified as "dormant deep" (Table 2.15-4, p. 2.15-23), and judged to pose low to moderate impact potential to the pipeline (Table 2.15-5).

Errors and Omissions - The Geology, Topography, and Mass Wasting Hazard maps (Map Atlas, p. 57-67) do not present a complete or accurate compilation of known faults along this portion of the pipeline route (see Carson and others 1987; Tolan and Reidel 1989; Reidel and Fecht 1994; Schuster 1994). As a result, the Application does an inadequate job of considering the potential seismic impacts of nearby faults on the proposed pipeline crossing sites.

The basic conclusion of the Application that the proposed pipeline route crosses no faults with evidence of Quaternary-age displacement is incorrect. The proposed pipeline route crosses and comes into close proximity to several potential Quaternary faults. Examples include:

- The syncline shown on the northeast side of Ryegrass Mountain (p. 61a, Map Atlas) is in fact a fault (see Carson and others 1987; Tolan and Reidel 1989).

- Reported Quaternary-age displacement on the north-south-trending fault on the Hog Ranch Anticline (Bentley and Powell 1987) noted in the regional structural geology compilation map by Tolan and Reidel (1989).

- Northwest-trending faults on the eastern flank of the Hog Ranch Anticline (Ryegrass Hill) in addition to those depicted on the route maps (p. 57-59, Map Atlas). The age of last movement on these faults have not been determined, but they are part of the same geologic structure that produced the sag ponds and should be considered potentially active.

- North-south cross faults associated with the Frenchman Hills and the Saddle Mountains (Tolan and Reidel 1989) along the western approach to the Columbia River and at the Columbia River (Mackin's 1955 Wanapum fault). Recent seismotectonic evaluation of this area by Geomatrix (1990; 1996) judged that faults associated with the main structural trend of the Frenchman Hills and Saddle Mountains are potential active and pose a creditable threat of generating moderate to large magnitude (ML5 to 7+) events. The north-south cross faults are kinematically linked parts of the main Frenchman Hills and Saddle Mountains fault systems. Consequently, there is a high potential for movement (deformation) on these cross faults if the main faults move.

Another significant aspect of the potential hazards to the pipeline posed by earthquakes the effects of strong ground motion. The Application examined this aspect by evaluating the potential peak ground acceleration that the pipeline would be exposed to during earthquakes and evaluating the response of the geologic materials in which the pipeline is built. A critical aspect of this type of assessment is to identify likely seismic sources (location of potentially active faults/folds - i.e., Frenchman Hills, Hog Ranch Anticline, McDonald Springs and Boylston Mountain segments of the Saddle Mountains), maximum creditable earthquake event (magnitude), and proximity to the pipeline route. As noted above, the Application fails to recognize a number of Quaternary, or potentially Quaternary, faults that have been previously identified in this area. Consequently, no analysis of the seismic hazard (peak ground acceleration) posed by these structures in proximity to, and crossed by, the pipeline have been considered in the EFSEC Application. Failure to correctly identify the geologic structures introduces a significant component of error into hazard analysis because incomplete, inaccurate, and erroneous data is being utilized.

6.3.1.3 Recommendations

The errors and omissions related to proposed crossing site physical geologic conditions are tied to a failure to acquire and use applicable regional and site specific geologic literature and understand the processes that formed the geologic setting at the various crossing sites. Before continuing with the project we recommend the following activities be undertaken to address errors and omissions outlined above:

Previously prepared geologic reports dating as far back as the 1950's clearly describe regional and Wanapum Dam site conditions. A more thorough information review for the crossing sites needs to be undertaken in order to prepare a more accurate interpretation of actual site conditions, such as expected grain size ranges, presence of open framework materials, and location of bedrock highs.

Geophysical data used to identify boulders and the top of basalt bedrock needs to be reevaluated in light of existing borehole data showing actual boulder deposits and the top of bedrock. If geophysical data can not be correlated to known physical conditions directly observed from previously drilled geotechnical borings it should be discarded entirely because of its failure to identify prominent existing features.

Additional subsurface characterization is necessary. These studies must be designed to accurately characterize materials actually present at the site, which can be estimated from existing geotechnical studies for Wanapum Dam and by geologists knowledgeable about the physical properties typically associated with high energy cataclysmic flood deposits.

Prepare a comprehensive geologic description section where all physical geologic properties and conditions are presented, including grain size, cement, structure contours, and thicknesses.

Conduct a complete review of available geologic mapping and information to develop an accurate assessment of the basalt and structural geology of this area to serve as a basis for construction feasibility and risk evaluation.

Conduct field investigations of all known or suspected Quaternary faults and folds to determine recent deformation histories and establish hazards posed to pipeline.

Conduct seismotectonic evaluation and seismic exposure analysis for the pipeline route and proposed Columbia River crossings based on both past studies (e.g., Geomatrix 1988, 1990, 1996) and additional investigations (see above).

Based on the results of investigations outlined above, reassess risk and feasibility of each proposed alternative Columbia River crossing.

Consider drilling options within the Columbia River basalt.

The recommended geologic investigations should be undertaken at each of the alternative crossing sites to resolve inconsistencies in site interpretations and better characterize how actual site conditions will influence pipeline construction, repair, and operation discussed in later sections. In view of likely site physical conditions described herein relevant to cataclysmic flood gravel characteristics, basalt bedrock highs, fault and seismic conditions, and statements in the Application (that cobbles and boulders reduce the practicality of directional drilling and maintaining upon hole during pipe implacement and that basalt bedrock will make drilling difficult and time consuming) it is difficult to accept the conclusion that geotechnical studies completed for the project indicate suitable conditions exist for pipeline construction using HDD methods.

6.3.2 GROUNDWATER

The purpose of this section is to briefly summarize and then review Application statements as they pertain to groundwater conditions at the crossing sites. General conclusions of the review include:

- Additional, publicly available hydrogeologic literature relevant to crossing site ground water conditions needs to be reviewed

- Site specific aquifer physical properties, including river-groundwater cross communication, is not evaluated, but should be

- Because of the sensitive nature of fisheries habitat in the Columbia River at the proposed HDD crossing, a leak detection system and/or ground water monitoring plan should be prepared.

6.3.2.1 OPL Summary

Groundwater discussions relative to the crossing sites are limited to some general statements on groundwater velocity and water table depths. Dames and Moore (1997, pg. 38) presents a spill scenario at the proposed HDD crossing that indicates groundwater movement through the sand and gravel substrate beneath the river channel is relatively slow. Water table depths in borings CC-1 and -2 were also measured at the time the borings were drilled. No other information is provided indicating the known or suspected groundwater conditions at the crossing sites.

6.3.2.2 Errors and Omissions

The Application fails to present technically sound interpretations of groundwater conditions at and beneath the crossing sites. However, previously published reports describe the hydrologic properties of the unique, open framework cataclysmic flood deposits likely overlying basalt at all of the proposed crossing sites to the extent necessary to begin to access groundwater conditions in the immediate areas of the crossings. For example:

- Publicly available hydrogeologic information from cataclysmic flood deposits at the Hanford Site (DOE 1988; Connelly and others 1991, 1992; Swanson 1992) show that these strata typically have saturated hydraulic conductivities on the order of hundreds to thousands of feet/day, and as high as 25,000 ft/day.

- This general conclusion is born out at the Wanapum Dam Site where Galster (1989) reports permeability (hydraulic conductivity?) of 820 to 8200 ft/day in the openwork cataclysmic flood gravel present at the site.

- The open framework texture of cataclysmic flood deposits (e.g., lack of fine matrix and cement) and abundance of large gravel clasts also argues for strong hydraulic connectivity between the aquifer directly underlying and adjacent to the river channel and the river proper.

All of these factors suggest it is likely that the Columbia River at all of the proposed crossing sites is in direct and rapid hydraulic connection with groundwater in cataclysmic flood deposit aquifers underlying and adjacent to the river channel. Consequently, construction and leak impacts on such aquifers near the river crossing have a high potential of impacting the river as well. In addition, no discussion of bedrock and overlying sediment aquifer cross communication is presented in the Application so that potential impacts on basalt aquifers of construction and operation can be evaluated.

6.3.2.3 Recommendations

Recommended activities for accessing actual groundwater conditions as they pertain to the pipeline center on reviewing relevant, already published reports and site specific data. Activities recommended to access groundwater conditions include:

Review of existing literature to fully incorporate what is known about the hydraulics of cataclysmic flood gravel and connectivity between aquifers in this material and the adjacent Columbia River into the site investigation. From this, demonstrate an understanding of the site specific physical conditions that control groundwater movement, gained through literature review and site specific hydrogeologic investigations

Evaluate groundwater flow rate, aquifer-river connectivity, and vertical and horizontal gradients in aquifers at the crossing sites through site specific investigations designed to provide a technically defensible basis for leak scenarios and impact assessments

Prepare a groundwater monitoring plan to monitor the closely connected river and cataclysmic flood deposit aquifer

Access potential hydrologic cross communication between basalt and overlying sediment aquifers.

6.3.3 SURFACE WATER

This section concentrates on Columbia River physical conditions as they exist in the river and the river channel. This section does not describe issues and impacts related to pipeline construction and operation. These are described and evaluated in subsequent sections. General conclusions of the review include:

An assessment of Columbia River water use at and some distance downstream of proposed crossings is lacking and should be compiled

Criteria used in preparation of, uses of, and construction and operation activities prescribed by the hydrologic sensitivity ratings are not explained, and should be

Relationships between depth of river channel scour, location of bedrock, and HDD boring location contain probable errors and need reevaluation.

6.3.3.1 OPL Summary

The Application's discussion of the physical setting of the Columbia River crossing seems to center on two main topics, hydrologic sensitivity and channel scour.

OPL developed hydrologic sensitivity ratings for each stream crossing, including the Columbia River. This rating is based on stream gradient, erodibility, width, and DNR stream type. It is used to provide a relative comparison of more or less sensitive stream crossings. Table 3.3-5 presents the results of this sensitivity rating for each of the crossings. The Columbia River crossing is rated as a 9, the maximum rating given to any stream is 11.

Stream channel scour was also estimated for the proposed HDD crossing site in Dames and Moore (1998). This estimate assumed scour is highest when river transport potential (the ability to hydraulically transport coarser bottom sediment) exceeds sediment supply in the river reach in question. Dames and Moore (1998, pg. 9) indicate a maximum potential depth of scour depth of 24 feet.

6.3.3.2 Errors and Omissions

The hydrologic sensitivity rating contains apparent errors and raises several questions. Scour depth estimates at the HDD site present major problems in pipeline construction and operation in light of probable site conditions. Other data concerning the Columbia River and its sensitivity to impacts are lacking.

Hydrologic sensitivity described in Table 3.3-5 contains an apparent error. On the table, in the Relative Rating Value column description for DNR stream type, it is stated that type 1 waters (e.g., larger streams supporting fisheries, recreation, and water supply uses) should be rated as a 5. However, the table column labeled Index Rating Values lists DNR type 1 streams as only a 3. Assuming the 3 is an error, and that type 1 streams should be given a rating of 5, a recalculated sensitivity rating for the Columbia River is an 11.

Whatever the correct sensitivity rating for the Columbia River is, 9 or 11, it is not clear in the Application what the significance of the rating is. OPL does not clearly state what the hydrologic sensitivity ratings calculated in Table 3.3-5 are to be used for. For example, how does a rating of a 9 or 11 differ from that of a 5 or 6 and what are the differences in proposed actions necessitated by the different ratings. If construction and operational activities are not influenced by the rating, what is the point of the rating.

Another significant problem with the Application discussion of surface water centers on channel scour and the previously described failure to accurately characterize the geologic conditions at the proposed HDD crossing site. The estimated maximum depth of scour presented in Dames and Moore (1998) is 24 feet. Sedimentary strata underlying the river channel and overlying basalt bedrock may be as thin as 20 ft thick (based on Mackin's 1955 work). Consequently, maximum channel scour may only be limited by depth of bedrock. Therefore, if the pipeline is to be installed solely within sedimentary strata overlying basalt bedrock, it will be located above the maximum scour depth.

Columbia River water uses and quality, both at and downstream of the various crossing alternatives, are not discussed explicitly any where in the Application. Potential existing uses both at and downstream of proposed crossings that need to be acknowledged include recreation, drinking water, fisheries, and irrigation supply.

6.3.3.3 Recommendations

Minimum recommendations to address surface water issues include the following:

- An explicit description of specific Columbia River uses and quality at and downstream of the crossing sites needs to be prepared

- The uses of the hydrologic sensitivity ratings need to be explicitly described, including actions and activities during construction and operation that will be undertaken at stream crossings as a result of different ratings

- Resolve the issues surrounding depth of scour and eventual pipeline location relative to scour, through characterization activities such as those recommended in previous sections.

6.3.4 FISHERIES RESOURCES

The purpose of this section, as with preceding sections, is to summarize OPL statements concerning fisheries resources at the crossing sites and to review these statements.

6.3.4.1 OPL summary

Fisheries information relative to the Columbia River crossing sites is presented in Dames and Moore (1997b) and summarized here. Dames and Moore (1997b, pg. 28) states that the HDD crossing site probably provides spawning and summer rearing habitat for anadromous salmonids, especially fall-run chinook salmon. On this page it also is stated that other species of anadromous salmonids migrate past the crossing site. However, Tables 4, 5, and 6 in Dames and Moore (1997b) all state that the crossing site is not spawning habitat.

Additional comments concerning fisheries resources center on the techniques used to construct the pipeline and leaks. These topics will be addressed in following sections about pipeline construction and pipeline operation issues and impacts.

6.3.4.2 Errors and Omissions

The Application contains notable errors regarding fisheries resources at the proposed HDD crossing, as well as inconsistencies. Comparing statements made in Dames and Moore (1997b, pg. 28) with those made in Tables 4, 5, and 6 of that report reveals a striking inconsistency. Page 28 suggests salmonid spawning habitat probably is present at the HDD site, while siting criteria summarized on the tables state spawning habitat is not present. Is, or is not, salmonid spawning habitat present at the HDD site, or any of the other proposed crossing sites?

Publicly available information not cited in Dames and Moore (1997b) resolves this inconsistency. Rogers and others (1989) clearly map fall chinook salmon redds along the west shore of the Columbia River over the proposed HDD location. Their Figure 5 is reproduced here as Figure 3. They reported a total of 408 redds at this site in 1987 (Rogers and others 1987, pg. 37). Additional spawning census data collected in 1989, 1990, and 1991 reported 492, 130, and 257 redds, respectively at this site (D. Dauble, PNNL field notes and personal communication 1999). In all likelihood, the HDD crossing site is actively used by spawning fall chinook salmon ever year.

Additional issues we see with fisheries information in the Application includes the following:

No clear descriptions of each crossing with respect to fisheries at that location is presented

Considering the intensity of the ongoing debate on Columbia River salmonids, the Application lacks a clear review of threatened and endangered species status and the specific actions OPL may need to undertake if listings are made and subsequent recovery plans prepared

The Application provides little information on the toxicity effects on salmonids of fuels transported through the pipeline, mitigation techniques that may need to be undertaken to protect these fish, and how construction and operation activities would be effected by potential species recovery activities.

6.3.4.3 Recommendations

Recommendations center on obtaining and evaluating data from Grant County Public Utility District (GCPUD), Washington Fish and Wildlife Department, Pacific Northwest National Laboratory, and federal agencies on endangered species, spawning grounds, toxicity values species present in the Columbia River at the proposed crossing areas. This information would then provide a basis for preparation of habitat protection and mitigation plans that are currently lacking.

6.4 CONSTRUCTION, REPAIR/RECONSTRUCTION, AND PIPELINE ABANDONMENT ISSUES AND IMPACTS

6.4.1 INTRODUCTION

The following sections present a summary of the construction-related impacts and mitigating measures for the Columbia River Crossing as proposed and discussed in the Application and supporting documents; along with identified errors and omissions from the Applications and recommendations for additional information and/or studies. General conclusions include:

Construction, repair, and maintenance details for all of the crossings except the HDD are essentially lacking

X For the proposed HDD crossing, site geologic controls on drilling, drilling fluid loose, d installation are inadequately addressed

X Seismic vulnerability for all of the proposed alternatives is not evaluated

X Except for drilling pad areas tailings disposal, mitigation proposals to protect the river m construction impacts are largely unexplained.

X Site access, permits, and regulatory issues (outside of EFSEC jurisdiction) are not plained.

6.4.2 APPLICATION SUMMARY

In Table 9.1-4 of the Application, OPL proposed nine potential alternatives to cross the Columbia River. The alternatives were ranked on order of preference based on cost and environmental impacts, and five alternatives were chosen for further study. The five selected alternatives include:

Attaching the pipe to the I-90 Bridge

Crossing on the Wanapum Dam (the pipe would be attached to the dam)

A horizontal directional drilled (HDD) crossing south (downstream) of Wanapum Dam

Attaching the pipe to the Burlington Northern Santa Fe Beverly Railroad Bridge

Placing the pipe on the river bottom north of the I-90 bridge

Table 9.1-4 of the Application rates the first four alternatives listed above, as geotechnically feasible with no environmental impacts. The fifth alternative, burying the pipe in the river bottom north of the I-90 Bridge, is also listed as geotechnically feasible, but with potential impacts to aquatic habitat and shorelines. The Application states that the proposed HDD crossing south of Wanapum Dam is the preferred alternative.

The choice of this alternative appears to be mainly due to the lack of access granted by current owners of I-90 bridge, Wanapum Dam, and Beverly Railroad bridge. The draft EIS also indicated that the Beverly Railroad Bridge is considered structurally deficient to carry the pipe and would require substantial and costly upgrading. Direct burial north of I-90 bridge is considered the least desirable alternative because of concerns of sedimentation impacts on the river and limited construction access (Application Sec. 2-14).

The Application implies that proposed HDD crossing location downstream of Wanapum Dam as generally favorable and feasible for the reasons listed below:

The river is at its narrowest point within the proposed routing corridor (Sec. 9.1)

Geotechnical studies completed to date (Dames & Moore 1998) indicated suitable geologic conditions to insure a reasonable chance for constructing the crossing using HDD (Sec. 2.14)

Approximately 130 ft of sand and gravel, overlying basalt bedrock present below elevation approximately 360 ft, provides good conditions for placing an HDD approximately 50 feet below the river channel (Dames and Moore 1998)

The potential for hydraulic fracturing during construction is low because of depth of the HDD bore is at least 30 ft below the river channel (Sec. 2.10)

The installed pipeline will have little or no maintenance needs because it is not exposed to weather and not subject to bridge work or replacement

The maximum estimated depth of channel scour, 24 feet, is not deep enough to reach a pipeline installed at depths greater than 30 feet.

The Application identified accumulated sediment washing into the Columbia River during construction activities as construction impacts at the I-90 and Beverly Bridge crossings. Identified construction-related impacts for the dredged crossing north of the I-90 Bridge include shoreline impacts, release of substantial quantities of sediment into the Columbia River which would have severe impacts to water quality and fish habitat, and limited access for construction equipment (barges, dredges, etc) due to the presence of Wanapum Dam. The Application, draft EIS, and the Dames & Moore report (1998) identifies the following as potential construction impacts from the proposed HDD crossing:

The need for large cleared areas on both sides of the river to accommodate the drilling operation and pipe assembly. Large cleared areas will impact vegetation and increase erosion potential

Disturbance to sensitive areas along the river by construction equipment access

Possible release of drilling fluid (bentonite) into the environment due to leakage through permeable units, hydrofracturing during attempts to free drilling tools, and from surface spills.

The Application presented the following general mitigation measures to minimize construction-related impacts:

At bridge crossings, best management practices (BMP) similar to those for road crossing and entrances would be employed to minimize the amount of sediment accumulating on the bridge as the pipe is suspended

Accumulated sediment would be removed on a daily basis. Though no discussion is presented for the Wanapum Dam crossing, we assume that similar BMPs would also be used

The HDD operation will be setback a minimum of 100 ft from the watercourse to minimize the potential for flooding and erosion

Temporary sediment traps will be used to catch sediments generated during drilling

Soil cuttings and accumulated sediments will be disposed of by appropriate methods

After completion of the work, disturbed areas will be stabilized by mulch or other erosion control methods.

Oil based drilling fluids will not be used

Drilling fluids will be contained in basins which will be designed to hold all circulating fluids

Under no circumstances, will drilling fluids be allowed to discharge from the basins or the surface of the drill site to any stream

The depth of the crossing should be sufficient such that hydrofracturing during drilling should not occur. In addition, the Application indicates that the potential for hydrofracturing of the deposits during drilling will be further reduced by careful monitoring of drilling fluid pressures.

6.4.3 ERRORS AND OMISSIONS

The following summarizes errors and omissions that, in our opinion, should have been addressed in the Application. Section 4.3.1 discusses the four alternative crossing, Section 4.3.2 discusses the proposed HHD crossing.

6.4.3.1 Alternative Crossings

The four identified alternative crossing of the Columbia River (I-90 and Beverly Railroad Bridge crossing, Wanapum Dam, and the dredged crossing) are potentially feasible. However, the Application does not include sufficient information to adequately evaluate the costs, impacts, and relative ranking of the proposed alternatives. Specific issues include the following:

- Although identified in the Application as alternative routes, the I-90 and Beverly Railroad Bridge crossings and the Wanapum Dam crossing have little discussion of potential construction-related environmental impacts and potential mitigation measures

- At the two potential bridge crossings (I-90 and Beverly Railroad Bridges) and at Wanapum Dam, the Application does not describe provisions for protecting the exposed portion of the pipeline from possible damage from vandalism, or as a result of damage to the bridge and/or dam itself. This information needs to be provided before the feasibility of these routes can be evaluated and compared

- The Application does not appear to discuss the seismic vulnerability of the exposed pipeline at bridge abutments or other transitional areas, or how the pipe will be protected from damage due to differential shaking between the ground and structures

- No discussions/details are provided for protecting the pipeline from damage where it is laid along the bottom of the Columbia River at the dredged crossing north of I-90. With the exception of the first 120 ft of pipe, the pipe will lay exposed on the bottom of the river

- A product spill analysis was not presented in Appendix B-2 that addressed any of the alternatives except HDD.

In general, butt-welded, steel pipelines have a great deal of flexibility and can usually tolerate significant deformation from ground shaking during a seismic event provided distortions (the rate of change of deformation along the pipe length) along the length of the pipeline remain generally small. In areas where the ground characteristics change suddenly, such as at the boundary between liquefiable soil and non-liquefiable soil or soil and bedrock, or were the pipe transitions from buried in the ground to attached to a structure, large distortions, which can damage the pipeline are possible.

6.4.3.2 Horizontal Directional Drilling

Though Table 9.1-4 in the Application states that HHD crossing is geotechnically feasible, in Section 2-14 of the Application, it is stated that "In unconsolidated soils, such as glacial till, and where cobbles and boulders are present, directional drilling may not be practical because the hole cannot be maintained to pull the pipe through." It appears that there is considerable uncertainty as to the feasibility of successfully completing the crossing. The Dames & Moore Report (1998) and the draft EIS provide additional discussions of potential methods that could be employed to improve the chances of successfully completing the crossing. These include the selective use of casing, grouting from the surface, and redrilling the hole. The feasibility, construction impacts and mitigation of these methods should be discussed in the Application.

As discussed in previous sections of this report, the description of site conditions may be inaccurate. If bedrock is present at shallow depths, the pipeline may not be able to be installed deep enough to be below the potential scour zone. Though some boulders were identified in the geophysical survey, the characterization of the expected geologic conditions along the bore fails to account for the possible abundance of boulders in the cataclysmic flood deposits overlying basalt bedrock, the open framework and uncemented nature of these strata, and the possible location of the bedrock surface underlying cataclysmic flood deposits at a relatively shallow depth below the river bottom. The impacts of these factors on the feasibility of successfully completing the crossing include:

Boulders could cause the drill string to deflect, thereby making it difficult to maintain hole alignment. Pullout and redrilling would be necessary

Potential for the drilling tools to be come struck due to hole collapse. Attempts to free the tools could result in hydrofracturing of the deposit

Loss of circulation of drilling fluids into the surrounding formation. Drilling fluids could reach the river if the bore is shallow

If bedrock is encountered along the bore, the drill bit will likely follow the contact of the bedrock and overburden, causing the bore to deflect off the alignment. This could likely prevent successfully completion of the crossing.

The Application indicates that the fluid pressures during drilling will be carefully monitored to reduce the potential for hydrofracturing and releasing bentonite drilling fluid into the environment. Where the bore is relatively deep, the potential for hydrofracturing is relatively low, though if the drilling tools become struck, and the contractor attempts to free them, hydrofracturing is a distinct possibility. Of particular concern is if permeable layers (open framework gravel) are present near the surface or near the banks of the river. Since the bore will be much shallower at these locations, drilling fluid could migrate to the surface or into the river as the bore passes through these layers.

The proposed size of the staging areas appear to be generally adequate if the pipe is to be assembled in sections as it is pulled back through the hole. In unstable ground, stopping to assemble sections of the pipe is generally avoided to reduce the potential for borehole instability and/or freezing of the pipe in place due to friction. Therefore, it is usually desirable to pull the pipe back in a single continuous operation without stopping to weld together sections. If the pipe is pulled back in a single continuous operation, the area required for pipe layout will need to be much greater than described in the Application.

The Application indicates that the product pipe will be pulled back through the hole. Provided the bore beneath the river can be successfully completed, it is our opinion that the pipe has a significant risk of being damaged during the pull back. In unstable ground, it is possible that a cobbles and/or small boulders could become lodged against the pipe, denting and/or gouging the pipe during the pull back operation. This could reduce the structural integrity of the pipe resulting in a future leak/failure of the pipe. If the pipe is pulled back in sections, the potential for borehole instability will likely be greater, increasing the possibility of damage. The potential for pipe damage during the pull back should be considered in the Application.

Since the pipe is proposed to be at a relatively great depth below the river, it will not be directly accessible for easy repair. Methods of repairing the pipe and methods for containing a release should be addressed in the Application. This discussion should include an evaluation of repair and alternative methods of transport while the pipeline is out of commission. Depending of the severity of the leak, repair may take a significant amount of time and could require redrilling of the crossing and installing a new pipeline. In either case, pipeline use and reliability would be impacted.

6.4.3.3 Regulatory and Permit Issues

These issues are summarized from a letter by D. Ancona of Grant County PUD (GCPUD) to A. Fiksdal (EFSEC) and F. Rogalski (USFS) on December 17, 1998. The subject of this letter is GCPUD's comments on the Cross Cascade Pipeline DEIS. The issues outlined in this letter applicable to this report include:

Requests for permits and the required supporting materials necessary to get permission to cross GCPUD property and rights of way have not been completed and submitted to GCPUD. These materials must be completed prior to granting of access to HDD site

Land use plan exemptions will need to be filled and accepted by GCPUD, possibly following a public comment period

Amendments to GCPUD's Federal Energy Regulatory Commission operating license may need to be filled for. This amendment would require the submittal of materials describing the pipeline and its impacts on GCPUD lands and operations

In addition, WSDOT and Burlington Northern Santa Fe Railroad may have similar requirements for attaching the pipeline to their respective bridges. For the dredged crossing, permits will be required from the Corp of Engineers.

6.4.4 RECOMMENDATIONS

The Application should be expanded to provide a more thorough discussion of the alternatives. Recommendations include:

Explanation and evaluation of pipeline protection alternatives for the I-90 and Beverly Railroad Bridges and Wanapum Dam crossing should be included in the Application

A discussion of seismic vulnerability and methods that will be used to minimize damage should be included in the Application

No discussions/details are provided for protecting the pipeline from damage where it is laid along the bottom of the Columbia River at the dredged crossing north of I-90. With the exception of the first 120 ft of pipe, the pipe will lay exposed on the bottom of the river. These discussions should be included in the Application

Further geotechnical investigation are warranted to resolve uncertainties in the geology. We recommend that a series of over water borings be completed every 200 to 300 ft along the crossing alignment. In addition, additional investigation/ explorations should be completed to verify if bedrock is present at relatively shallow depths along the crossing. This information should be included in the Application. The draft EIS and the Dames & Moore report (1998) recommend drilling a pilot hole to verify the feasibility of the crossing prior to full mobilization of the equipment. We recommend that a pilot hole be drilled to assess the feasibility of the crossing

The Application should address drilling fluid loss

Specific mitigation measures that will address damage to the pipe during pull back need to be discussed

The Application needs to prepare a discussion of all of the permit/regulatory requirements for the proposed crossing sites. This discussion should include how the requirements will be met and a schedule for meeting the requirements (including agency and public comment cycles beyond the EFSEC process).

6.5 OPERATIONAL ISSUES AND IMPACTS

Once in place, operation of the pipeline poses potential risks to the surrounding environment. OPL statements concerning operational risk issues and impacts are summarized below, followed by our comments as they relate to rapid/catastrophic leaks, slow leaks, water quality, and fisheries. The conclusions of our review are summarized as follows:

Operational leak scenarios prepared for the crossings are inadequate and inconsistent

Catastrophic events impacting operation and reliability of the pipeline need to be addressed

Alternative installation designs need to be evaluated for their potential to reduce operational risks

Operational monitoring at the proposed HDD crossing, where direct observation is impossible, needs to be identified.

6.5.1 OPL SUMMARY

Operational issues and impacts of the pipeline at the Columbia River crossing alternatives are described in Dames and Moore (1997b). This report explores leak/spill scenarios along the pipeline route, and proposes a single scenario for the Columbia River crossing, a long term (slow) leak of 13,100 gallons. The scenario is characterized as a moderate volume leak over a long period of time. Impacts are interpreted to be variable, but only significant (or high) over a small area in the immediate presence of where fuels might seep out of the bed of the river into the river. Additional assumptions within this scenario as they relate to pipeline operation issues and impacts include:

Spill is detected by visual inspection

Response occurs within 3-days of leak initiation

Climatic conditions inhibit volatilization

Slow groundwater flow coupled with adsorption of fuel slows dispersal of leak into river

Mixing and dispersion will be rapid in the river with little fuel reaching the river's surface

Acute toxicity will occur in immediate vicinity of fuel seep with the duration of the seep controlled by bacterial degradation and groundwater flushing of river bottom sediments

Additional information supplied in the Application indicates operational issues and impacts will be handled and controlled through such measures as inspections, pipeline performance monitoring, regular maintenance, and planning.

6.5.2 ERRORS AND OMISSIONS

Insufficient discussion is devoted to operational issues and impacts at the Columbia River crossing sites in the Application. The assumption of the Application seems to be that operation of the pipeline poses no risk to the surrounding environment. In addition, with respect to the proposed HDD crossing this option seems to be assumed to be inherently superior because "...installed pipeline would have little or no maintenance need..." (Application, pg. 9.1-36). The following sections briefly review potential operational issues and impacts not addressed in the Application and the supporting leak assessment (Dames and Moore 1997b).

6.5.2.1 Ruptures, Rapid Leaks

A pipeline rupture and resultant rapid leak scenario is not explicitly addressed in the Application. However, pipeline operations are threatened by three potential natural trigger mechanisms for initiating a rupture and rapid leak which can be shown to be present.

Faults/Seismicity - As discussed in previous sections (Sec. 2.1.2.5), the proposed route crosses one fault in mid channel (Wanapum fault) as well as being located in close proximity to others. The mid-channel Wanapum fault is connected to at least the Saddle Mountains fault. These faults are kinematically linked to recognized Quaternary faults (Saddle Mountains and Frenchman Hills faults) and should be recognized as potentially active. Movement on any of the Quaternary-aged faults at or near the crossing would trigger ground motion in the immediate vicinity of the pipeline. Sufficient strong ground motion could trigger rupture adjacent to or beneath the Columbia River, disable check valves in the vicinity of the river crossing, and result in a significant rapid release of fuel into the Columbia River. There is no recognition or evaluation of such a potential in the Application. Consequently, no design or mitigation considerations are given for this threat.

Mass Movements - The preferred proposed approach route to the proposed crossings at and below Wanapum Dam and at the Beverly Bridge crosses a large landslide 3 to 4 miles north of the dam. This feature is described as dormant, although without any supporting documentation describing the basis for this conclusion. Because of this, no design or mitigation measures are proposed. However, selection of this route to the river necessitates an evaluation of the feature to determine what the triggers for previous movements were and if pipeline construction and operation will reactivate these triggers. Human reactivation of the mass movement leading to pipeline rupture would result in a fuel spill onto the ground immediately upslope of the Columbia River. Such a leak would drain into the Columbia River.

Scour - If the projected bedrock high beneath the river channel described in section 2.1.2.4 is present, it will force shallow emplacement of the pipeline in gravels underlying the channel, given OPL's current HDD scenario (drilling in gravel, avoiding bedrock). If emplacement is shallow enough, the pipeline will be placed within the potential scour window projected in Dames and Moore (1998) for the river channel. Consequently, during high flow and increased scour a catastrophic rupture might occur as a result of erosional undercutting and destablization of the pipeline.

Potential rupture triggers, such as outlined above, require engineering, monitoring, and mitigation measures that are not discussed in the Application.

6.5.2.2 Slow Leaks

The slow leak scenario presented in Dames and Moore (1997) is based on assumptions that may not, given probable site conditions as described in section 2.1.2, be representative of Columbia River crossing conditions. Examples include:

Migration of fuel from leak to river probably will be rapid given high Ksat of cataclysmic flood deposits and their openwork texture, unless porespace sealed

If leak occurs, fuel will reach river fast at relatively high concentrations because of low retardation potential of detrital, silt poor, organic poor cataclysmic flood deposits.

Additional variables and criteria that were not factored into any consideration of leak scenarios include:

Visual detection criteria for a leak appear very optimistic, especially in view of Application suggestions that river mixing will disperse leak to such an extent that little fuel will reach the surface of the river

Use a scenario more reminiscent of the Renton spill, long lasting, slow detection, seepage away from the immediate location of the route

Timing, during salmonid migration and/or spawning

Fuel concentrations in the river and their acute and chronic toxicity to salmonids, and effects on eggs, fry, redds, and migration patterns.

6.5.2.3 Impacts of Repair and Replacement on Operations

The statement that the installed pipeline will have little or no maintenance is more an admission of the inaccessibility of the pipeline beneath the river than of the inherent superiority of burial to minimize repair requirements. If maintenance is required the proposed depth of burial beneath the Columbia River will make it essentially impossible to directly access the pipeline for repairs and maintenance. The only way to directly access the pipeline in case of a leak will be excavation in the river (which is extremely difficult given river conditions and proposed depth of burial) or from within the pipeline (for which options will be very limited). If an unrepairable leak occurs beneath the river pipeline operations will need to be suspended until a new pipeline can be built. In either case, interpretation of fuel deliveries to eastern Washington will be interrupted, and with the reduction in truck and barge tankers, not easily made up. None of these issues and impacts are discussed in the Application.

6.5.2.4 Water Quality and Fisheries

Both slow leaks and ruptures will impact water quality and fisheries. All comments centering on aerial extent of fuel plumes, concentration levels and duration of leak, and water quality effects and fish toxicity are explained only in the most qualitative terms, or not al all. Quantitative risk assessment or modeling is not described for providing a basis for evaluating impacts to the river and aquatic habitat. Downstream impacts to recreation, irrigation use, and water supply are not systematically explored using any evaluation or calculations describing how a leak will disperse or mix in the river. A concise technical discussion or justification is not given for any of the conclusions describing the effects of leaks on the river environment.

6.5.3 RECOMMENDATIONS

The Application should provide substantiated/discussions regarding the potential environmental impacts to the Columbia River on a number of issues. Specific recommendations include:

Slow leak and/or rapid release due to pipeline damage at the proposed two bridge crossing, the Wanapum dam crossing, or the dredged crossing north of I-90 need to be evaluated

The Application needs to address the operational impacts in case of a nonrepairable leak beneath the river requiring complete pipeline replacement and interruption of fuel deliveries to eastern Washington

Details regarding spill prevention should be included in the Application

Provide scientific and engineering justifications for all conclusions.

6.6 CONCLUSIONS

The Application materials relevant to discussion of the Columbia River crossing options are poorly organized, contain internal inconsistencies, and are not technically defensible. Specific issues with the Application include:

The poor organization of the Application is reflected in a lack of clear, accessible descriptions of crossing site geologic, groundwater, surface water, and fisheries conditions. Physical conditions at the crossings are simply not described clearly before conclusions are drawn about their impact on pipeline construction and operation

Where physical conditions are described, errors are present, generalizations are taken as representative of site specific conditions, and qualifying conditions are not defined

Publicly available regional and site specific information that was noted cited in the Application directly contradicts and/or calls into question conclusions presented in the Application as they relate to site conditions

Conclusions, rating schemes, and justifications for proposed actions are often not supported by documented evidence upon which they were presumably based. In addition, some ratings appear to serve no discernable purpose

Conclusions about risk relative to construction and operational impacts appear very optimistic, lack explanation and quantitative support, and lead to a lack of proposed effective monitoring, protection, and mitigation activities.

7.0 TOLT RIVER CROSSING SPILL SCENARIO

7.1 INTRODUCTION

The purpose of this chapter is to illustrate the potential effects of a large rapid release of fuel at a location where there are significant surface water and fisheries resources downstream of the leak location. At the location chosen for the spill, there are significant geologic hazards that could damage the pipeline causing it to leak. Spill impacts include:

Impacts to fisheries resources

Impacts to surface water resources

Impacts to groundwater resources

Interruption of pipeline service.

7.2 SETTING

7.2.1 DESCRIPTION OF SPILL LOCATION

The postulated spill occurs at the proposed Tolt River crossing, in King County . At this location, the pipeline trends northwest-southeast across the valley of the Tolt River. The river is divided by an island at the proposed crossing. As a result, there are currently two Tolt River crossings (i.e., stream crossings 26 and 27 in Olympic Pipe Line Company (1998 [Application], Atlas Page Number 11). The main channel is located on the north side of the island.

7.2.2 GEOLOGY

The pipeline approach to the Tolt River begins from the north. The pipeline would be located at an approximate elevation of 500 ft (Application p. 3.1-25) on rolling topography composed of glacial till (Qgt on Atlas Page Number 11; and briefly described on p. 3.1-3). The proposed route runs southeast as it crosses the Tolt River, which is incised almost 400 ft into glacial and non-glacial sediments. Proceeding southeast from the glacial till (Qvt), the pipeline sequentially would cross recessional outwash deposits of boulder and cobble gravel deposits (Qgo), and a unit described by Booth (1990) as deeply weathered older (nonglacial and glacial) sediments (Qpf) and by Turney and others (1995) as transitional beds of clayey silt and clay (their upper fine-grained unit), and Tolt River alluvium (Qa) on the floodplain of the Tolt River. The Tolt River alluvium is described as cobbly and pebbly sand in Booth (1990). Proceeding southeast up the south side of the valley, the pipeline would pass close to or cross a small area of alluvial fan deposits (deposited from a tributary drainage) mapped by Booth (1990). These fan deposits are not shown on Atlas p. 11 and are not discussed in the text (Application p. 3.1-3). The pipeline would next cross landslide deposits (Qls) and, farther up the slope, glacial till. The Soil Types and Erosion Hazard Map (Atlas Page Number 11) indicate that soil located on glacial till (near the tops of the slopes) has moderate to high erosion hazard.

A boring was drilled close to the proposed pipeline location on the south side of the Tolt River (about 23 ft south of stream crossing No. 27) as part of the project investigations (Dames and Moore 1996). The soil from the surface to a depth of 20 ft is described as poorly graded gravels with variable amounts of fine to coarse sands. The gravel is underlain by silty sand and sandy silt to a depth of 39.5 ft. This deposit appears to be the upper fine-grained unit (Qpf).

The hillslope gradients near the Tolt crossing are reported to be, on the northwest slope, generally less than 65% (30^o) with several sections of slightly steeper slope; and on the southeast slope, generally steeper than 65% (Application p. 3.1-25).

Landslide deposits are common in the Tolt Valley. The contact between the fine-grained deposits (Qpf) and the overlying coarse-grained deposits (Qgo) is described as a landslide hazard in the Seattle area (Galster and Laprade 1991). Booth (1990) has mapped landslide deposits on both sides of the Tolt valley at a scale of 1:50,000. Presumably, additional, smaller slides exist that do not appear at this map scale. The slides mapped by Booth have affected parts of all the deposits on the valley walls, including the glacial till.

The stream channel at the proposed crossing location is subject to lateral erosion (also called stream channel migration) and scour. The Tolt River channel reportedly migrates across the floodplain (Brown 1996, p.2; Dames & Moore 1996, p. 8; West Consultants 1997, p. 8; U.S.D.A. Forest Service 1998 [DEIS], p. 3-22;). The north bank of the main channel has been riprapped to protect the county road and private residences during frequent flooding. Brown (1999) stated that as recently as 15 years ago, the main channel of the Tolt River flowed where the side channel is currently located. The 100-yr flood plain at this location is reported to be 257-ft wide (Application

p. 3.3-52). According to West Consultants (1997, p.8) the depth of vertical scour in the Tolt channel is possibly greater than their model suggests. Dames & Moore (1996) reported that the lateral instability at this crossing is strongly influenced by accumulations of large woody debris because the debris can cause rapid relocation of the river from one side of the valley floor to the other. They also reported that the random nature of woody debris accumulations makes evaluation of stability and scour at this site difficult.

7.2.3 SURFACE WATER BODIES

The Tolt River is a DNR Type 1 stream (Application, Table 3.3-6) and it has been given an Ecology Class Rating of AA (Application, p. 3.3-8). The Application states the present channel slope varies from 0.7% (side channel) to 1.0% (main channel). According to Nelson (1999), the river has a pool-riffle morphology. The average monthly flows vary from an August low of about 6 to a December high of about 27 cubic meters per second (Application, Figure 3.3-3).

The Tolt River is utilized by chinook, coho, chum, and pink salmon. Steelhead trout, cutthroat trout, western brook lamprey, sculpin, and mountain whitefish also utilize the river at the crossing (Application p. 3.4-114). The side channel is dominated by boulders and cobbles, but the Application (p. 3.4-64) reports spawning gravel on mid-stream bars. The mainstream and side channel have summer rearing habitat and the side channel has winter rearing habitat (Nelson 1999).

Fuel spilled into the Tolt River would flow toward the Snoqualmie River, which is less than 3-miles to the west. The Snoqualmie River is also a Type 1 stream. It has an Ecology Class Rating of A and is listed as having temperature as a water quality limiting factor (Application, p. 3.3-8). According to Nelson (1999), the Snoqualmie River has a pool-riffle morphology near its confluence with the Tolt River, but becomes a sand-bedded regime channel a short distance downstream. Average monthly discharge varies from an August low of about 32 to a December high of about 164 cubic meters per second. The mainstem of the Snoqualmie River is utilized by chinook, coho, chum, and pink salmon for transportation, spawning and rearing (Application p. 3.4-64). Other species that occupy the Snoqualmie River are listed in Table 3.4-9 of the Application.

Chinook salmon (all stocks) have been proposed for listing as threatened within the next year (Application p. 3.4-164). The other salmonids present in the Tolt and Snoqualmie Rivers have recreational, commercial and tribal importance.

7.2.4 GROUNDWATER CONDITIONS

Turney and others (1995) provides information on the groundwater conditions in the vicinity of the proposed Tolt Crossing. They report an aquifer in the Tolt River alluvium which is continuous with an alluvial aquifer in the Snoqualmie River valley. They describe this aquifer as the most permeable geologic unit in eastern King County, with a median hydraulic conductivity of 130 feet per day. Turney et. al. (1995) also report a deeper aquifer, which they refer to as the upper coarse grained unit. They indicate the top of this aquifer is located at an elevation of approximately 200-feet below sea level. The two aquifers are separated by the upper fine-grained unit (Qpf), which they report is a confining bed (i.e., an aquitard). This confining unit is located beneath the Tolt River alluvium (Turney at. al. 1995, Plate 1). Water Well Reports provided by Ecology and the boring by Dames & Moore (1996) indicate the alluvial aquifer is about 20- to 30-ft deep in the vicinity of the Tolt River crossing.

The Water Well Reports further indicate domestic wells may be located within one-quarter mile of the proposed pipeline route. Some of these wells were constructed on properties located on Tolt River Road (the road on the north side of the Tolt River). Brown (1996), whose property is also located on Tolt River Road, reports his 80-ft deep well is located 100 ft downhill from the proposed pipeline route. The relatively shallow depths of many of the domestic wells suggests they draw water from the alluvial aquifer.

7.2.5 LAND USE

The Application (p. 2.1-7) notes that the proposed right-of-way crosses second and third growth forest. The area is currently commercial forest land, but much of it has been converted to residential subdivisions that are as yet largely undeveloped. Dames & Moore (1996) includes a map that shows a building approximately 640-ft west of the proposed route. Brown (1999) reports new house construction within one half mile downstream of the proposed crossing and a Girl Scout camp on the south side of the river near Langlois Lake.

The city of Carnation is located about one mile downstream of the proposed crossing. The Stillwater Unit of the Snoqualmie Valley Wildlife Area is located near the confluence of the Tolt and the Snoqualmie Rivers. The postulated spill site can be accessed from roads in and above the valley.

7.2.6 TOXICITY OF DIESEL FUEL

Information on the ecological toxicity of refined petroleum was obtained for this spill scenario. The information includes acute toxic concentrations to fish and other aquatic organisms and chronic toxic concentrations to fish.

Information summarized in American Petroleum Institute (API 1995) indicates a concentration of 50 mg/L of refined petroleum product dissolved in water is a reasonable estimate of the acute toxicity to rainbow trout. This value is called the LC50, or the lethal concentration in the water that kills 50% of the test organisms in a 90-hour static aquarium test. The concentration varies with many factors including the crude oil from which it was refined and how it was refined.

Markarian et. al. (1992) provide information on the acute toxicity of specific petroleum products, including diesel fuel, to fish, invertebrates and algae. Their data are drawn on a large number of studies, many of which may not be specific to the species present in the Tolt River. In addition, toxicity data to all the various life stages of many of the test organisms was not available. Markarian et. al. (1992) express toxicity in terms of ALethal Loading@. Unlike the traditional notation of LC50, which describes the amount of a single dissolved chemical constituent needed to cause impact, their Lethal Loading concept quantitates the toxicity of the product in terms of the amount of pure product added to water to cause a 50% mortality (or lethal loading) to test organisms (i.e., LL50). They reported the following median LL50 concentrations for diesel fuel: fish, 45 mg/L; invertebrates, 6.6 to 41 mg/L (varies with life stages); and algae, 50 mg/L

Woodward and Riley (1983) and Woodward and others (1983 1987) provide information on the chronic toxicity of refined petroleum product to fish. Chronic exposure can affect growth, reproduction, swimming ability and other physiological conditions. These effects do not directly kill the fish, but affect them in some deleterious manner such as making them unable to avoid predators or unable to properly reproduce. The range in concentrations for chronic effects of refined petroleum to cutthroat trout is 24 to 39 µg/L (i.e., about 0.1% of the acute toxic concentrations).

7.3 SPILL EVENT

7.3.1 CONDITIONS AT TIME OF SPILL

The release occurs some time in the future when the pipeline is operating at its full design capacity of 4,182 barrels per hour (2,927 gallons per minute). This figure is 80% of the maximum achievable flow rate for diesel in the Thrasher to Kittitas segment (see Application p. 2.3-35).

Changes in the Tolt River channel configuration have occurred. At the time of the spill, the main channel is south of the current location of the side channel and about 100-ft north of the landslide deposits.

The postulated rupture occurs at the toe of the landslide deposit on the south side of the river (just south of crossing number 27). There are a number of geologic hazards that could cause a leak or rupture to occur here or on the north side of the river. For example, the deep seated slide on the south side (Application p. 2.15-24) could be reactivated during a prolonged period of increased precipitation, by a moderate earthquake or both. This slide was rated as having a high hazard potential from mass wasting (see Application p. 2.15-28). Also, during a major flood event the river could quickly migrate across the flood plain and erode the toe of the slide, which could cause it to slip further. In addition, lateral erosion or vertical scour of the channel could expose the pipe to the forces of water, sediment and woody debris in the Tolt River (Dames & Moore 1996; West Consultants 1997). Finally, the soil in this area is considered to have a high liquefaction hazard potential (DEIS p. 3-19). Earthquake-induced liquefaction of the soil surrounding the pipe could lead to rupture of the pipe.

For the rupture event, it is assumed the deep seated fault is reactivated during a moderate earthquake and the pipeline completely breaks at the toe of the slide. The rupture event occurs in October when the discharge of the Tolt River is 13 cubic meters per second and the discharge of the Snoqualmie is 75 cubic meters per second (Application p. 3.3-13). The temperature is in the range of 50 to 60 degrees F, there is a westerly breeze at 5 to 10 mph, and there is a light steady rainfall. The specific gravity of the diesel fuel is 0.84, the viscosity is 4.6 cP, and the vapor pressure is 2 psia (Application p. 2.3-35).

There would be two block valve locations near the spill event, one at Milepost 23.42 and the other at Milepost 24.56 (Application, Table 2.9-2). For the rupture event, it is assumed both valves close automatically as soon as possible after the rupture is detected and that neither valve is damaged by the earthquake or landslide.

7.3.2 PIPELINE RUPTURE

The pipeline rupture would release approximately 59,800 gallons of diesel fuel. This was determined as the entire volume between the two block valves (48,100 gallons), plus the volume that would flow during the 4-minutes it reportedly takes for the pumps to shut down and the block valves to close (11,700 gallons) (see Application, p. B-1 of the spill scenarios). This is likely an underestimate of the volume released because of potential delayed manual closure of the block valves and because of possible leaks through the valves.

7.3.3 MOVEMENT OF DIESEL

The following assumptions are made concerning the behavior of the spill:

Fuel would be released so quickly that much of it flows out onto the ground surface.

20% of the diesel fuel released (12,000 gallons) evaporates either before or after reaching the river.

40% of the fuel released (24,000 gallons) mixes with water in the Tolt River over a time period of 60 minutes and remains dissolved and dispersed in the river. After reaching the river, no diesel is sorbed to sediment or the shoreline.

40% of the fuel spreads out on an area 60-ft wide and 100-ft long (the distance to the river) and soaks into the permeable, alluvial soil 6-ft to the water table. The 6-ft water table depth is based on the bank height information in the Application (p. 2.14-25).

Obviously, these percentages are contingent on site conditions and would be different if the rupture occurred in a different location. For example, a rupture beneath the river would release essentially all the fuel to the river.

7.3.3.1 Concentration of Diesel in River Water

The diesel enters the Tolt River and mixes with the turbulent water. The overall concentration resulting from mixing the diesel fuel and Tolt River water over a 60-minute time period is 1627 mg/L. This concentration exceeds the solubility of diesel in water. Consequently, much of the fuel would be dispersed in the water column in the form of many tiny drops and kept in suspension by the turbulence of the river (see Overstreet and Galt 1995). Furthermore, the concentration of diesel fuel would probably remain much closer to saturation in the Tolt River than if the diesel was present as a slick on the comparatively calm surface of a lake or pond.

The diesel contamination would reach the Snoqualmie River after about 1.4 to 2 hours based on an estimated velocity of 2 to 3 feet per second for the Tolt River (Nelson 1999). The concentration of diesel after mixing with water in the Snoqualmie River would average 240 mg/L. This concentration assumes the diesel fuel and water of the Tolt River completely mixes with water in the Snoqualmie River over a 1-hour period. However, it is more likely the waters from the two rivers will not initially mix completely. The diesel plume will probably remain on the east side of the river until it reaches the first bend where secondary flow around the bend will cause the waters to mix. In addition, the Snoqualmie River is less turbulent and more turbid than the Tolt. This may cause some of the fuel to coalesce and float to the surface where it will evaporate at a faster rate and some of the fuel to sorb onto suspended particles. Also, because there is less turbulence (and mixing), diesel concentrations (and toxicity) will probably vary considerably in the river.

Before its confluence with the Skykomish River, diesel concentrations in the Snoqualmie River would be somewhat diluted by water inputs from small tributaries, such as Harris Creek, Cherry Creek, and Tuck Creek, and possibly from groundwater discharges. In addition, other process such as evaporation and sorption would cause further reductions in concentrations. However, until results from a trajectory model for the Snoqualmie River demonstrate otherwise, the possibility exists that lethal concentrations will persist in parts of the Snoqualmie River as far as its confluence with the Skykomish River.

7.3.4 IMMEDIATE IMPACTS

7.3.4.1 Tolt and Snoqualmie Rivers

Considering the toxicity of diesel to fish and the overall concentration of diesel in rivers, the rupture would cause a major kill of fish, invertebrates and algae in the Tolt River between the pipeline crossing and the Snoqualmie River. There is also a high probability of significant mortalities in the Snoqualmie River, perhaps as far downstream as the Skykomish River. In addition, the impact of the contaminated river water will extend down into the coarse bed alluvium (i.e., hyporheic flow) and kill most of the eggs, fry and invertebrates present.

Species and age classes present have to be considered in order understand the impact that a spill in October would have on salmonids. At that time of year, adult chinook are actively spawning. Adult steelhead are holding in the pools or locations where there is cover. During odd years, if not already spawning, adult pink salmon would also be holding in the deeper pools. The subyearling salmon present would include coho, chinook, steelhead, and cutthroat. Yearling steelhead and cutthroat would also be present, as well as adult cutthroat. Assuming the estimated concentrations, most if not all the salmon and trout within the lower 2.5 miles of the Tolt River would be killed. The chinook eggs and developing embryos in the redds would suffer very high mortalities. Some individuals may try to avoid the diesel plume by swimming downstream. However, because of low flow conditions, movement by fish within the Tolt is restricted making avoidance difficult. Fish not immediately killed by the diesel may die later from sublethal physiological affects.

Because of the depth of the Snoqualmie, adults and larger juveniles are better able to avoid the diesel. However, a significant number of subyearlings and a few yearlings are killed along the east side of the river. Concentrations are likely to remain high enough that chinook eggs deposited in redds in the Snoqualmie also suffer significant mortality. Because of the higher levels of fine sediment and organics in the Snoqualmie, some contamination sorbs to the suspended particles. This would reduce the concentration of dissolved contaminants but also create conditions where sub-lethal concentrations will persist in patches along the margin of the channel that could result in additional latent mortality.

7.3.4.2 Sediment

This scenario does not evaluate the possibility that fuel would mix with mud derived from the landslide and be deposited in the Tolt River. Landslides often have associated debris flows and erosion. In the event a landslide occurs, the delivery of large volumes of fuel and mud to the Tolt and Snoqualmie Rivers would be likely. The mixture of fuel and mud may result in lower short term (i.e., acute) diesel concentrations and higher long term (i.e., chronic) concentrations.

7.3.4.3 Soil

In this scenario, 40% of the diesel fuel (about 24,000 gallons) soaks into the ground. If the fuel were to spread out, soak in, and thoroughly mix with the soil resulting in Aresidual saturation@, approximately 35,600 cubic feet of soil would be affected. This volume was calculated assuming a 0.3 soil porosity, a residual saturation of 0.3 of the pore volume, and uniform soil conditions. In reality, the fuel would likely seep more quickly into the soil in some locations, reach the water table (estimated at 6-ft below ground surface), and spread out. Where this occurs, the area of contaminated soil at the water table could be larger than the area at the surface. The Afree product@ floating on the water table would be close enough to the Tolt River, that it could slowly seep from the soil into the river, serving as a secondary source.

7.3.4.4 Groundwater

In this scenario, there is no free product floating on the water table. If there were, however, some of the free product will dissolve into the groundwater. Contaminated groundwater close to the Tolt River may reach the river within a day or two and contribute additional contamination. In this scenario, wells are not immediately affected because no wells are located close to the spill site.

7.3.5 IMMEDIATE RESPONSE

The rupture is discovered immediately and the pipeline is automatically shut down. OPL personnel and a response trailer are mobilized and arrive at the spill site within one hour of the release. Cleanup contractors are contacted and arrive at the site within two hours of the release. Other contractors have been contacted to deploy booms downstream of the spill to protect sensitive areas and population centers.

Due to the turbulent mixing of the fuel with the water in the Tolt River, the sheen is very dispersed and difficult for response personnel to visually track or recover using booms. In addition, much of the fuel has reached the Snoqualmie River by the time they arrive. Consequently, very little diesel fuel is recovered from the Tolt River. Response efforts along the Snoqualmie River consist of placing booms along sensitive shore areas and trying to sorb floating patches of product. However, very little product is recovered.

Nearby residents, not served by municipal water systems, are notified of the spill and told to use bottled water.

In this scenario, response crews arrive immediately and are able to begin cleanup and repair. However, this may not always be possible. For example, the postulated landslide may not appear stable enough for people and equipment to work on or near, especially if a mud flow occurred. In the event of an earthquake, fear of aftershocks and damage to public works may slow response time or make personnel respond less predictable ways. The landslide may take days to stabilize before the pipeline can be repaired and contaminated mud cleaned up. Consultants may have to be called in to evaluate the situation.

7.3.6 LONG-TERM IMPACTS

7.3.6.1 Tolt and Snoqualmie Rivers

The previous discussion demonstrates that diesel fuel will be dispersed in the water column of the Tolt River and transported downstream. Some of the fuel will sorb to the shoreline sediment, shoreline vegetation and stream bed sediment. Fuel will also remain in soil and groundwater at the spill site. These areas of fuel Astaining@ slowly dissolve and remain sources of contamination. Because the chronic toxic concentration of petroleum in fish is low (i.e., tens of parts per billion), impacts to fish are likely to occur for a long time (i.e., months to years). The presence of low levels of contamination also leads to avoidance behavior in fish and other organisms.

The impacts to chinook and many other salmonids (e.g. steelhead, coho, and cutthroat) will persist over several cycles of the year class impacted. These impacts persist because chinook fry that emerge from a redd and survive to maturity do not all return at the same time. Some return to spawn as two year olds, some as three year olds, and so on. All other things being equal, a reduction in the number of returning adults is likely to persist for at least 5-years. The mortalities caused by the spill will reduce the harvest of adults.

A fuel spill into the Tolt during odd years, when pink salmon spawn, would be particularly devastating. Pink salmon return only as two year olds, so no overlap of year classes occurs. Consequently, a reduction in population size caused by a petroleum spill would last for a much longer period.

7.3.6.2 Sediment

Sediment contaminated during the spill would be present in the stream bed and in lower energy portions (e.g., pools) of the river system. The contaminated sediment will impact the habitat of the Tolt and Snoqualmie Rivers. Depending on a number of variables such as flushing, oxygen content and sunlight, the fuel compounds will chemically degrade. Some contaminated sediment may deposit as far downstream as the Shohomish River and degrade habitat there.

7.3.6.3 Soil

Much of the soil at the spill site would probably be cleaned up to regulatory standards. However, because of difficult access and the likelihood that intrusive cleanup would do more harm than good, some contaminated soil would be left in place. Water would drain through this contaminated soil, and leach some of the contaminants. The leachate would reach the water table and be transported to the river and/or domestic wells.

7.3.6.4 Groundwater

Groundwater located beneath the spill site would remain contaminated as the water table fluctuates across the Asmear zone@ (fuel-contaminated soil at the water table). Free product is assumed not to be floating on the water table If it is, however, groundwater contamination will remain at levels of concern. Contaminated groundwater could migrate to the river or domestic wells.

Contaminated groundwater that reaches the river can contribute to long term (or chronic) toxicity impacts and avoidance behavior. Contaminated groundwater can also reach wells. The Water Well Reports provided by the Ecology do not show any wells near the postulated spill site. Most wells near the river appear to be on the north side of the river. However, the Water Well Reports for wells near the spill site may have been incorrectly prepared (a common occurrence) or may not have been submitted. If wells are present, it is possible for low concentrations of contaminants to reach wells that pump water from the shallow alluvial aquifer because this aquifer is hydraulically connected to water in the river. Additional information is needed to evaluate impacts to groundwater.

7.3.6.5 Interruption of Service

A pipeline spill caused by an earthquake-induced landslide is likely to cause an interruption in use of the pipeline for a period of time, perhaps days to weeks long. If a fuel shortage develops or is eminent in eastern Washington, fuel will probably be brought in by truck. Depending on the number of trucks required, a fuel shortage could occur.

7.3.7 LONG-TERM MITIGATION

In the situation described, there are likely to be a number of long term activities. A geotechnical evaluation would be conducted of the landslide. Landslide mitigation is likely to include an engineered solution and increased monitoring.

There is likely to be monitoring of conditions where contaminated soil and groundwater are present. This may last for years and would probably include testing domestic wells in the vicinity of the spill site. For comparison, the Renton spill site is still being monitored at levels above regulatory standards 15-years after the spill occurred.

There would almost certainly be studies of conditions in the watershed to evaluate recovery of salmon stocks and river ecology. These would also go on for years.

8.0 NORTH BEND SPILL SCENARIO

8.1 INTRODUCTION

The purpose of this scenario is to illustrate the reasonably likely impacts from a slow leak of petroleum product from the proposed Cross Cascade Pipeline (CCP) in the City of North Bend area. The City of North Bend is a moderate size community of about 3,100 approximately 30 miles east of Seattle. The sole source of the City=s water supply is from groundwater, through a spring source. The City also currently has a conditionally approved permit to develop a well head source. Based on its size and reliance on groundwater and proximity to surface water, North Bend is not unlike other small communities in the Snoqualmie Valley or eastern, Washington along the CCP route. A leak or spill of petroleum product has the potential to create a significant impact on the human and environmental health of the City and its surrounding community.

8.2 SETTING

The City is located in King County in township 23 north, range 8 east, sections 3, 4, 9 and 10. Most of the City population is situated above Snoqualmie Falls between and adjacent to the South and Middle Forks of the Snoqualmie River. The CCP crosses the South Fork of the Snoqualmie River (stream crossing 42, Application Table 3.3-6) at approximately milepost 36 and heads southeast through the heart of the City along the Burlington Northern Railroad right-of-way. The pipeline route passes adjacent to the North Bend Elementary School at approximately milepost 37 before connecting to the North Bend pumping station at milepost 37.2 (p. Table 2-9.2). East of the pump station the CCP passes a mobile home park and a cemetery prior to again crossing the South Fork of the Snoqualmie (stream crossing 43) at about milepost 39.3. Both river crossings are on railroad bridges.

The pipeline is 14 inches in diameter and is buried beneath 36 inches of dirt (p. 2.3-9). In the North Bend area, the CCP has six block valves at milepost 31.86 (valve #7), milepost 34.06 (valve #8), milepost 37.32 (valve #9 at the North Bend pump station), milepost 37.34 (valve #10), milepost 39.42 (valve #11), and milepost 44.29 (valve #12). The area around North Bend is particularly susceptible to a pipeline leak or rupture. Block valves are acknowledged as a potential cause of leaks (although they will generally reduce the volume of a release) and the majority of the releases from the existing pipeline system have been at pump stations or block valves (Jones and Stokes 1998, p. 3-141). The six block valves at the City of North Bend represent the highest density of valves along the entire proposed route. The North Bend pump station also has the highest pipeline operating pressure (1690 psig, p. 2.2-9). Other high risk factors include its location in a seismically active region of the state located near the suspected (but not documented in the Application) Quaternary Rattlesnake Mountain fault (Woodward Clyde, 1992). Also, the location of the City is in an area likely to experience substantial growth and consequently can expect an increasing risk of third party pipeline damage.

8.2.1 SPILL DESCRIPTION

A product spill or rupture in the vicinity of North Bend is possible or even likely over long term operation of the pipeline. For purposes of this spill scenario, it is assumed that a leak occurs at the North Bend pump station block valve (milepost 37.2). The leak is small, approximately 50 gallons/hour, about 0.025 % of the operating flow rate of the 14 inch pipeline of 110,000 barrels per day (192,500 gallons/hour). This rate is also below the detection of the SCADA pressure monitoring system or inventory control detection methods. The leak is small relative to transport volume of the pipeline and automated leak detection systems but it is substantial relative to human health based drinking water quality standards and ecological toxicology. The location of the pump station is shown on the attached Figure.

8.2.2 HYDROGEOLOGY

Though not identified in the Application, the City of North Bend is located over one of the most productive aquifer systems in western Washington. This aquifer system referred to as the North Bend Aquifer (City of North Bend 1998) or the Upper Snoqualmie Aquifer (East King County Groundwater Association 1998) is capable of supplying enough water to serve 500,000 people has been identified as a regional water supply source.

The geology of the area consists of a thick sequence of recent alluvium (Qal) underlain by a thick sequence of Vashon age recessional outwash deposits and pre-Vashon deposits. The alluvial deposits in the vicinity of the pump station consist of approximately 20 feet of moderately permeable alluvium consisting of sand and gravel, silty gravel and cobbles, and silt. This soil horizon is underlain by over 200 ft of higher permeability sand, gravel and cobbles (RH2 Engineering 1997). These alluvial deposits represent the uppermost groundwater flow systems that would be impacted by a leak or spill in this area. Because of the permeability contrast between the upper and lower alluvium, these deposits represent two hydraulically connected but distinct water bearing zones. In this spill scenario, the upper alluvium is termed Zone 1 and the lower alluvium is termed Zone 2.

The hydraulic conductivity of the alluvium in general is estimated at a median value of 130 ft/day and a maximum value of 1,800 ft/day (Turney et. al. 1995). At the existing City of North Bend test well, the aquifer transmissivity was estimated at about 1,000,000 gal/ft/day (RH2 Engineering 1997). Assuming a 200 ft thick aquifer, the hydraulic conductivity of the lower alluvium can be estimated at about 700 ft/day. For purposes of this evaluation, the upper 20 ft of alluvium, or Zone 1, is assumed to have a hydraulic conductivity of 200 ft/day. The lower deposits, or Zone 2, are assumed to have a hydraulic conductivity of 700 ft/day.

Water levels in Zone 1 vary seasonally from between about 5 ft and 10 ft below the ground surface in the vicinity of the postulated spill. Similarly, water levels in Zone 2 vary seasonally from between about 8 ft and 12 ft below the ground surface under static or non-pumping conditions. Consequently, there is a slight natural downward hydraulic gradient between Zones 1 and 2 during most times of the year. Municipal and domestic supply pumping in Zone 2 locally depresses the water table to 25 ft below ground surface in the vicinity of the municipal pumping well. Consequently, stronger downward gradients occur in the vicinity of this well and domestic supply wells.

Precipitation is estimated at about 80 inches/year (Sumioka et. al. 1998); infiltration is estimated between 41 and 50 inches/year (Turney et. al 1995) in the vicinity of the City. Consequently, Zone 1 is recharged by precipitation at the water table surface. Much of this recharge flows laterally towards the rivers within Zone 1, however a significant portion of Zone 1 groundwater flow also recharges the upper portion of Zone 2. The upper portion of Zone 2 is also in hydraulic continuity with the both branches of the river. Groundwater discharge form Zone 2 is toward both branches of the river and to municipal and domestic supply wells that tap this zone.

Groundwater flow in the aquifer zones beneath the City is complicated by the proximity of the South and Middle forks of the Snoqualmie river, the high but seasonal rates of recharge, and water supply pumpage. Under static conditions, a groundwater divide occurs in Zone 1. The divide runs approximately north-south paralleling the direction of the two river branches above their confluence. The divide is assumed to be roughly equidistant between the two systems. The groundwater divide is however not static. It shifts locally depending on the relative river stage of the Middle Fork and South Fork of the Snoqualmie. The seasonally average location of the groundwater divide intersects the pipeline at the north end of the pump station in the near vicinity of the pump station block valve at milepost 37.32. The groundwater divide in the upper portion of Zone 2 is similar to the groundwater divide in Zone 1 under static conditions. However under the spill scenario conditions, the location of this divide is strongly influenced by pumping wells.

Groundwater hydraulic gradients in the upper Snoqualmie valley in the alluvium and recessional outwash deposits are estimated to be at least 10 ft/mile (Turney et. al 1995) or about 0.002 ft/ft under non-pumping conditions. This groundwater gradient is similar to the South Fork of the Snoqualmie River gradient in the vicinity of North Bend. In the vicinity of the postulated spill, the actual hydraulic gradient in Zone 1 is estimated to be about 0.004 in the summer due to pumping effects in Zone 2. In the winter the gradient increases to as much as 0.008 due to high rates of precipitation recharge. In Zone 2, the average gradient is strongly impacted by pumping wells. The gradient is estimated to be equivalent to an average gradient of about 0.01 towards the City of North Bend=s pumping well PW-1.

8.2.3 WATER USE

The alluvial aquifer is a critical resource for both consumptive and non-consumptive resource water users. Consumptive water users include local exempt well users, the City of North Bend, the EKCGWA, and the City of Snoqualmie. Non-consumptive uses include a city park, fisheries in the Snoqualmie Rivers, and recreation uses.

8.2.3.1 Groundwater Uses

The City of North Bend has an exploratory well in this aquifer under a preliminary permit approval from the Washington State Department of Ecology. This well is currently located approximately 145 ft from the CCP at about milepost 37. The permit allows for the instantaneous withdrawal from this well of 5903 gpm. The groundwater supply is being developed to help the City comply with surface water treatment requirements of the Clean Water Act that apply to their current spring source. For the purposes of this spill scenario, it is assumed that the City is forced to abandon their current well because of the proximity to the pipeline alignment and redrill a permanent water supply well at the west end of Si View Park, approximately 2500 ft from the pump station. The North Bend Elementary School is located between the CCP and this well.

The East King County Groundwater Association (EKCGWA) under preliminary permit approval applications (G1-27384 and S1-22877) is evaluating the feasibility of developing approximately 40 MGD of water. The EKCGWA=s Area 1 well field is located in the direct vicinity of the North Bend pumping station. Under a preferred development alternative (Golder and HDR Engineering 1998), the groundwater will be pumped into the river near the City and be intercepted and treated at a treatment plant near the City of Duvall approximately 15 miles downstream. The well field will consist of number of wells tentatively located in and around the City (see attached figure). For the purposes of the spill scenario it is presumed that the EKCGWA decides not to install wells within the direct vicinity of the pipeline to comply with their groundwater management plan. The redesign and scoping of their Area 1 well field results in substantial consulting, management and agency negotiating costs.

In addition to serving as a direct resource, the Upper Snoqualmie Valley has been identified as a recharge area for deeper groundwater resources of the lower valley. In particular, the City of Snoqualmie has identified the North Bend area as a recharge area to both their north and south well fields. These well fields are approximately 2.5 miles down valley from the City of North Bend. Well depths exceed 500 ft (Bob Hansen 1998).

A number of exempt wells are also located in the pump station area. Two domestic wells and an irrigation well are located within 1000 ft of the pump station (RH2 Engineering 1997). In section 10, where the pump station is located, there are least 22 domestic or private well logs on file with the department of Ecology. Within section 10 there are 31 water rights claims, permits, applications or certificates listed in Ecology=s WRATs (water rights) database. The location of three nearby domestic and irrigation wells are shown on the attached figure.

8.2.4 SURFACE WATER USES

The South Fork of the Snoqualmie River is rated as a DNR Class 1 stream type (Table 3.3-6) with an Ecology Class A water quality rating (Table 3.3-2). The South Fork has average monthly flows that range from 5 m3/s to 25 m3/s (Figure 3.3-3). Fisheries utilization includes rainbow trout and cutthroat trout as well as a number of non-salmonid species (Jones and Stokes 1998) above Snoqualmie Falls. Below the falls, the river represents an important migration and salmon spawning water course for a number of salmonids including bull trout, dolly varden, fall chinook salmon, spring and fall steelhead trout, pink salmon, chum and silver salmon (Jones and Stokes 1998). Puget Sound bull trout and chinook have been proposed for listing as threatened species (Jones and Stokes 1998).

8.3 SPILL SCENARIO

A pipeline leak is postulated to occur at the North Bend pump station. Leak mechanisms could result from a defective block valve, corrosion or pipeline defect resulting from third party damage or seismic shaking. The pipeline leak is postulated to have occurred in late fall after winter rains have started and continues for about a year.

8.3.1 DESCRIPTION OF RELEASE

Block valve # 9 is located at the North Bend pumping station. The product release is a small valve leak, similar to Olympic=s Renton pump station valve leak. The leak rate is never quantified, but after the fact it is estimated at about 50 gallons/hr. The spill is not detected by OPL=s pressure monitoring system (SCADA) or inventory control systems. Because the leak is not immediately detected, the duration is also unknown but is later calculated at about 12 months. The duration of leakage is potentially less than the duration of leakage for OPL=s Renton leak. At the Renton leak, OPL apparently detected a pipe fitting leak at the station in January 1986 and at the time did not suspect a significant loss of product. Approximately 9 months later, in October 1986, OPL hired a consultant to investigate Aa potential subsurface leak@ (GeoEngineers 1986). In their initial progress report, the consultant identified a dissolved plume of petroleum constituents stretching from the pump station over 1200 ft downgradient to the Cedar River. At this time, detectable levels of benzene, toluene and xylene were present in the river.

The quantity of leaked product from this spill scenario is estimated to be approximately 438,000 gallons. The product type would include diesel, jet fuel, and gasoline. The spill volume for this scenario contrasts with an estimated 2000 barrels (84,000 gallons) leaked from OPL=s 1986 Renton spill. King County (King County 1996) presents the 2000 barrels as a minimum spill volume for the

Renton spill. GeoEngineers calculated a spill volume for the Renton spill at 80,000 gallons in 1986. It is not clear if this spill volume was updated since then but it is likely that it is an approximate estimate given the difficulty in estimating product mass in the subsurface and difficulties Olympic has had with characterizing the plume (CCA 1998). The City of Renton estimated the leak to potentially be two to four times the size volume estimated by GeoEngineers (CH2M Hill 1987). The Application lists at least six leaks at the Renton Station (ASC p. 2.9-3) however it is not clear from the Application text if the 1986 spill that reached the Cedar River is listed. Note that the cause of the Renton spill was apparently not conclusively determined by Ecology as late as 1996 (Ecology 1996).

8.3.2 CONTAMINANT MIGRATION

Migration of the plume occurs as a free phase product plume, a dissolved groundwater plume and a vapor plume. Initially the leaking product spreads out in the slightly more permeable trench backfill. Eventually, migration of the plume results in impacts to Zone 1 and Zone 2 groundwater, surface water and building air space underneath the plume.

The spill occurs in November. Rainfall is heavy resulting in high water content levels within the unsaturated zone. Because the trench backfill is slightly more permeable then surrounding native soil (hydraulic conductivity twice that of the native soil), perched water conditions or near saturated conditions exist at the bottom of the trench during periods of heavy rain. Consequently, the leak tends to spread out laterally along the trench backfill. The rate of migration in the trench is about 2.6 ft/day. This migration rate assumes:

An approximate horizontal hydraulic gradient in the trench of 0.004

An equivalent horizontal hydraulic conductivity in the trench of 400 ft/day

A porosity in the trench of 0.3.

A retardation rate of 2

A product mixture viscosity of less than 1.0 centipoise.

Note that a production well located in Mt. Si Park would have a 1 year travel time capture zone that encompasses the North Bend pumping station and the leak site based on well head protection zone estimates by the City of North Bend (RH2 Engineering 1997).

The product spreads out mainly to the north, down valley towards the Elementary School. By the time the leak is discovered after 12 months, the product in the trench has migrated along the trench about 1,000 ft. The product has also migrated vertically down to the water table within a few feet of the trench. This migration pathway creates a floating free product source at least 1,000 ft long that spans the groundwater divide in groundwater Zone 1.

A dissolved phase plume occurs in Zone 1 and starts to migrate advectively in the direction of groundwater flow direction. Because the source effectively straddles the groundwater divide, a plume moves east towards the Middle Fork of the Snoqualmie (the Middle Fork plume). A second plume moves northwest essentially along the pipeline alignment (the South Fork plume). The rate of plume migration of the South Fork plume is initially at about 5.3 ft/day based on the following conditions:

Hydraulic conductivity = 200 ft/day

Hydraulic gradient = 0.008 ft/ft

Porosity = 0.3.

The actual leading edge of the South Fork plume defined by methyl tertiary-butyl ether (MTBE) travels at a faster rate (by a factor of 1.2) due to longitudinal dispersion. BTEX (benzene, toluene, ethylbenzene, and xylene) constituents travel at a slower rate due to retardation (by a factor of 2). Over the six month period the plume spreads out in the downgradient direction within Zone 1 almost 2000 ft. BTEX concentrations spread out approximately 1500 ft from the source due to the combined migration of free product in the trench and dissolved phase in groundwater. At the time of discovery, the plume has migrated beneath the North Bend elementary school.

As the South Fork plume migrates to the north, the plume is gradually transported down into Zone 2. The rate of vertical migration increases substantially as the plume gets closer to the City=s pumping well. When the dissolved phase enters Zone 2 it migrates laterally at a rapid rate of approximately 20 ft/day based on the following parameters:

Hydraulic conductivity = 700 ft/day

Equivalent average hydraulic gradient = 0.01

Porosity = 0.3.

MTBE will travel substantially faster then BTEX constituents and other hydrocarbon fractions that make up the free phase product. At the above migration rate, the plume could travel the 2500 ft to the City production well in 125 days. Because of the slower migration rate in Zone 1, MTBE arrives in the City production well after about 250 days. The plume is detected during the next quarterly sampling event about 90 days later. This is about the same time a distinct odor is noticed in the North Bend Elementary School. Vapor concentrations measured in confined spaces around the school result in a few hundred ppmv total hydrocarbons. Benzene vapor concentrations are as high as 10 ppmv; toluene vapor concentrations are as high as 150 ppmv. These concentrations are well above the National Institute for Occupational Safety and Health (NIOSH) recommend exposure limits of 0.1 ppm and 100 ppm respectively. These concentrations are equivalent to confined space vapor concentrations detected during the Renton spill (GeoEngineers 1989).

Free product occurs throughout the source area stretching up to 1000 ft downgradient of the leak. Free product thickness varies from a sheen to over 1 ft. Soil concentrations within the source area vary considerably but exceed 10,000 mg/kg total petroleum hydrocarbons (as diesel). Groundwater concentrations within the source area exceed 10,000 ug/l for BTEX constituents and MTBE. Concentrations at the City supply well 2500 ft downgradient from the source are as high as 30 ug/l of MTBE; approximately 10 ug/l above proposed MTCA Method A cleanup levels. Benzene is also found but at concentrations slightly below MTCA cleanup levels.

Initial characterization activities focus on the South Fork plume. Given the complex recharge and discharge patterns in the area, the presence of the Middle Fork plume is not discovered until a sheen is detected in the river almost 4 months later. Concentrations measured as seepage into the Middle Fork are as high as 4 ug/l of individual BTEX constituents and MTBE. These concentrations are similar to concentrations detected in the Cedar River due to the OPL Renton spill (GeoEngineers 1986).

8.3.3 RESPONSE

The detection of MTBE in the City=s production well precipitates an immediate response. OPL, Ecology, the Department of Health, and the City are directly involved. Impacts of the spill are both short term and long term.

Short-term elements of the response include emergency remedial actions, repair of the pipeline, temporary evacuation of the school and emergency water supply measures. Long-term elements include building a high capacity treatment plant for the City of North Bend=s well, characterization of the plume, implementation of a long term remediation strategy, and structural upgrades to the elementary school to address foundation settlement caused by the remediation pumping, and a survey of other buildings to determine if they are likely to be damaged. As part of a longer term response, the City of Snoqualmie and the EKCGWA implement increased monitoring in groundwater and the river. To comply with their recently updated water system plans that address concerns associated with the pipeline, both entities are required to implement Phase I of their contingency plan that requires investigating the feasibility of alternate water supply sources. The costs to the City of Snoqualmie and EKCGWA are substantial.

Remediation is hampered by the location of the pipe line within the railroad right-of-way. Soil excavation requires an expensive shoring plan to stabilize the right of way. Groundwater pumping causes settlement of the railroad tracks that result in additional response costs to repair the railroad. The remediation is ongoing for over ten years. Ultimately, total petroleum hydrocarbon concentrations and concentrations of BTEX and MTBE constituents are reduced to state MTCA cleanup levels. Though cleanup levels are eventually achieved, residual petroleum constituents still remain within the soil matrix. The residual petroleum results in lower dissolved oxygen levels in groundwater and higher concentrations of dissolved iron and manganese. These constituents result in continuing treatment requirements for the City=s well. Use of groundwater for irrigation is terminated because of higher concentration of heavy metals cause crop damage.

9.0 SNOQUALMIE TUNNEL SPILL SCENARIO

9.1 INTRODUCTION

The purpose of this spill scenario is to illustrate the potential effects of a slow release of fuel at a location where there are human health and safety issues.

Spill impact issues include:

Fire and explosion

Injury and property damage

Potential impact to surface water

Potential impact to groundwater

Interruption of pipeline service

Interruption of communications.

9.2 SETTING

9.2.1 DESCRIPTION OF TUNNEL AND SPILL LOCATION

The Snoqualmie Tunnel spill occurs approximately 2200-ft west of the east portal of the tunnel (see Olympic Pipe Line Company 1998 [Application], Atlas Page No. 25) . The pipeline trends east-west through the Snoqualmie Tunnel, which is located near Snoqualmie Pass (elevation approximately 3200-ft) in the Cascade Mountains, Washington (see figure). The proposed design calls for cutting a trench in the floor of the tunnel and installing the pipeline in the trench. The Snoqualmie Tunnel is a large semi-confined space. If fuel leaks, vapors can mix with air and form an explosive mixture.

The Snoqualmie Tunnel is approximately 12,000-ft long, 15.2-ft wide and 22.5-ft high at the top of the roof crown. Typical dimensions and construction are given in GeoEngineers (1997). The east portal of the tunnel is located at an approximate elevation of 2590-ft; the west portal is located at an approximate elevation of 2520-ft. These elevations were determined from U.S. Geological Survey (1989).

The walls and roof of the tunnel are covered by a concrete liner that was cast in place. The liner, which is reportedly about 12-inches thick, is degraded in places (Application p. 3.1-31; Larsen 1998) . Water seepage reportedly occurs sporadically from the walls and roof of the tunnel and through the concrete liner.

According to GeoEngineers (1997) the floor of the tunnel consists of crushed rock (sand with silt and fine gravel) 0.1 to 0.6-ft thick. Beneath the crushed rock is medium dense to dense sand and gravel; and beneath that is railroad ballast consisting of fine to medium angular gravel with a trace of sand. The total thickness of the ballast and overlying fill varies from 0.6 to 2.1-ft.

Concrete lined drainage channels are located at the base of the north and south walls along the entire length of the tunnel. The drainage channels are approximately 2.1-ft wide and 1-ft deep. The channels are covered by wood planks and synthetic fabric, apparently to minimize collection of sediment. Water in the channels appears to flow toward the west (GeoEngineers 1997).

There appears to be significant water seepage into the tunnel most of the year. A July 30 1997 inspection reported significant amounts of seepage from cracks and joints in the tunnel liner (Application, p. 3.1-30). An investigation by GeoEngineers (1997) reported water seepage occurs sporadically from the walls and roof of the tunnel and through the concrete liner. Unfortunately, the report does not provide the date of the observations. Apparently, significant amounts of water were dripping into the tunnel, especially in the east end, when the bat survey was conducted on March 12 1998 (Larsen 1998). According to the Application (p. 3.1-31), the construction records indicate groundwater was encountered during the mining of the tunnel. In addition, groundwater seepage into the tunnel was reported in 1989-90, when AT&T installed a fiber optic cable in the floor of the tunnel. Apparently, there was enough seepage that AT&T repaired the drainage channels (Weber 1998).

According to the Application (p.2.3-18), the pipeline would be buried as it approaches and enters the tunnel. Except for the upper 6-inches, which is ballast material, the pipeline would be buried in rock. The ditch would be 24-inches wide and 36-inches deep. The pipe would have a 1-inch rock jacket and the backfill will include a covering with two inches of lean concrete poured flush with the rock floor of the tunnel. The Application Figure 2.3-5 displays a cross section of the tunnel showing the pipeline location.

9.2.2 GEOLOGY

The tunnel was driven through a geologic fold structure known as an anticline (roughly an upside down AU@) (Application, p. 3.1-31). The axis of the anticline is oriented almost perpendicular to the axis of the tunnel. The construction records indicate much of the rock was massive black slate (Application, p. 3.1-31).

According to GeoEngineers (1997), bedrock lithologies in the tunnel generally trend from consolidated sedimentary rock (i.e., siltstone) in the east, to metamorphic rock (slatey shale and quartzite) in the west. The transition is gradual.

Fractures, in places described as extreme, were reported to locally occur in the siltstone. The quartzite reportedly Aoften contains mineralized veins@ of milky quartz and pyrite or chalcopyrite. Mineralized fracture planes with slickensides were observed at one location in the floor of the tunnel. Outcrops near the west portal display abundant fractures with variable orientation and spacing of about 3 to 8-ft (GeoEngineers 1997). GeoEngineers (1997) concluded that trenching the bedrock would be more difficult in the western 4000-ft of the tunnel.

9.2.3 GROUNDWATER CONDITIONS IN THE TUNNEL

GeoEngineers (1997) provides information on groundwater conditions in the tunnel. Slow to rapid groundwater seepage was encountered in most of the 20 testpits dug in the floor of the tunnel. The groundwater was generally perched in the railroad ballast on top of the bedrock. The depth to groundwater seepage ranged from about 0.5 to 1.7-ft. Although there appears to be significant amounts of groundwater seepage into the tunnel most of the time, it is not clear from the GeoEngineers= report that shallow groundwater is present in the floor during the entire year.

9.2.4 SURFACE WATER BODIES

Several surface water bodies are located above the tunnel. Surveyors Lake (approximate elevation 3950-ft) is located above the tunnel approximately 3000-ft east of the west portal. Hyak Lake (approximate elevation 3900-ft) is located approximately 5500-ft east of the west portal and approximately 700-ft south of the tunnel. In addition, three creeks pass over the tunnel. These creeks, and their locations and elevations where they cross above the tunnel, are Surveyor Creek (approximate elevation 3760-ft), approximately 4100-ft east of the west portal; Hyak Creek (approximate elevation 3400-ft), approximately 5900-ft west of the east portal; and an unnamed creek (approximate elevation 2900-ft), located approximately 2500-ft west of the east portal.

Rockdale Creek is located within approximately 200-ft west of the west portal. The Application (Tables 3.4-8 and 3.4-9) indicate the crossing (crossing number 84) will be avoided. However, the Map Atlas (p. 24) shows the proposed pipeline route crossing the creek.

The confluence of Rockdale Creek with the South Fork Snoqualmie River is located approximately 1500-ft downstream from the west portal. According to the Application (p. 3.4- 82 and 116), there aren=t any fish in Rockdale Creek. However, this conclusion may have been based on a cursory survey. In order to fully evaluate the effects of a spill in the Snoqualmie Tunnel, the status of fish and other species in Rockdale Creek should be confirmed.

According to the Application (p. 3.4-115) the South Fork Snoqualmie River in the vicinity of North Bend contains cutthroat and rainbow trout as well as sculpin, mountain whitefish, western brook lamprey, large scale sucker and longnose dace. Presumably, some or all of these species utilize the upper portions of the river at various times during the year.

9.2.5 LAND USE

The Snoqualmie Tunnel is located on the John Wayne Trail System operated by Washington State Parks and Recreation (Application p. 2.3-18). The portion of the trail leading to the east portal reportedly is heavily used for recreation (Application p. 2.1-13). Approximately one-quarter mile east of the west portal, the Pacific Crest National Scenic Trail crosses over the tunnel. In addition to tunnel use by hikers, the tunnel is used by AT&T and MCI-Worldcom, which have fiber optic cables buried in the tunnel floor (Application p. 2.3-18).

The west portion of the tunnel is in the Snoqualmie National Forest and the east portion is in the Wenatchee National Forest. The Alpine Lakes Wilderness Area is located approximately 8-miles north of the tunnel.

The Hyak ski area is located approximately 1500-ft south of the east portal. Ski Acres and Pacific West ski areas are located north and south of the east portal. According to the USGS (1989), there are buildings and an electrical substation located within approximately 1200-ft of the east portal. Associated with the ski areas are a vehicle service station and store, housing and other structures, roads, parking lots, water supply wells, an electrical substation, a sewage disposal plant and other developments. Although the locations of many of these structures were not determined for this spill scenario, the full impacts of an explosion in the tunnel cannot be evaluated without this information.

The east portal of the tunnel is located within about 200-ft of the frontage road that connects the ski areas, and about 300-ft from the eastbound lane of I-5. The west portal is located about 320-ft vertically higher and approximately 1200-ft horizontally from the eastbound land of I-5. There are three entrance/exit ramps on the I-5 freeway in Snoqualmie Pass area. One of these, the Hyak exit, is located in the vicinity of the east portal. These distances and elevations were determined from U.S. Geological Survey (1989).

9.2.6 CLIMATE INFORMATION

Snoqualmie Pass has harsh weather. It receives over 102-inches of precipitation, much as snowfall, and has an average annual temperature of about 15 degrees C (Application p. 3.2-14).

9.2.7 THE FIRE TRIANGLE

9.2.7.1 Gasoline Flammability

Gasoline can form flammable or explosive mixtures with the cool moist air in the tunnel. The flash point of gasoline is B36 degrees F (-38 degrees C). Its lower flammable limit is 1.4% and its upper flammable limit is 7.6% by volume in air (EXXON 1997). Using the dimensions in GeoEngineers (1997) to estimate the air volume in the tunnel, vapor from approximately 2200 gallons of gasoline are required to produce a flammable or explosive mixture throughout the tunnel (Wagner 1999). Smaller volumes of gasoline can also create flammable or explosive conditions. For example, about 17-gallons of gasoline could produce an explosive vapor mixture in 100-feet of tunnel (Wagner 1999). Although the tunnel is cool, gasoline will still evaporate because it has a relatively high vapor pressure which varies seasonally between about 5 to 15 psi (EXXON 1997).

9.2.7.2 Oxygen

Oxygen would be in the air in the tunnel. The tunnel holds a lot of air B between 4 and 5 million cubic feet. GeoEngineers (1997) reports that when the breeze in the tunnel stopped for a few days, they didn=t operate the backhoe, presumably because of exhaust fumes. This indicates that stagnant air conditions can occur in this semi-confined space.

9.2.7.3 Ignition Source

A source of ignition is required in order for an explosion or fire to occur. There are several possible sources in this area. For example, one source could be humans smoking, operating internal combustion engines, operating electrical equipment, or operating a camping stove near one of the portals. Presumably, if anyone entered the tunnel while fuel was leaking, the fuel odor would be noticed and the person would leave and notify authorities. However, outside the tunnel portals, the odor may not be noticed, especially if people were working near internal combustion engines, which tend to emit a fuel odor. Since gasoline vapors are about three to four times denser than air, the vapors could migrate along the ground surface outside the portals until an ignition source is reached (e.g., a vehicle on the frontage road near the east portal).

Other ignition sources would be lightning, forest or brush fire, or sparks created by the movement of the pipes (there would be two and possibly three metal-sheathed fiber optic pipes in addition to the petroleum pipeline) against the bedrock during an earthquake. Another possible source of ignition could be a capacitance discharge off the pipes in the tunnel, if they become ungrounded. Finally, there is static electricity. Fires and explosions are sometimes initiated by static electricity.

9.3 SPILL EVENT

9.3.1 CONDITIONS AT THE TIME OF THE EVENT

9.3.1.1 Time of Event

The spill occurs in the month of August.

9.3.1.2 Weather Conditions

At the time of the spill event, it is warm (70 degrees F) and the relative humidity is approximately 40% at the pass. There is very little wind. The temperature inside the tunnel is assumed to be 45 degrees F.

9.3.1.3 Human Activity

A worker is preparing to remove brush with a chain saw near the east portal. Hikers are in the area but not in the tunnel or near the portals. There are vehicles on the frontage road and traffic on I-5 is heavy.

9.3.1.4 Groundwater Conditions

Based on the available information, it is reasonable to assume that the fill materials in the floor of the tunnel are saturated with groundwater and groundwater is flowing west in the drainage channels. However, groundwater conditions in August are not available.

Given these groundwater conditions, fuel that leaked into the Snoqualmie Tunnel would flow out of the pipeline trench through fractured rock and fill materials and form a floating layer on water in the ballast. Drainage conditions will spread the fuel westward in the tunnel, which will increase its surface area.

9.3.2 THE SLOW LEAK

9.3.2.1 Slow Leak Behavior

Corrosion has caused a small leak to form at 9 p.m. when nobody is in the tunnel. At this time, gasoline is moving through the pipeline at a rate of 5428 barrels per hour (i.e., 227,976 gallons per hour), which is the full operating capacity. According to the Application (p. 2.3-35), the full operating capacity for gasoline is 80% of maximum achievable flow rate of 6785 barrels per hour. The leak rate is approximately 0.2% of the operating capacity (i.e., 456 gallons per hour), which is too low to be detected by the SCADA system. By 9 a.m. the next morning, approximately 5500 gallons have leaked into the tunnel. Gasoline has spread on the shallow groundwater. Some gasoline has evaporated. The vapors have spread throughout the tunnel creating a range of fuel vapor to air ratios from lean at the portals to rich near the middle of the tunnel. In addition, gasoline vapors are moving out of the portals and along the ground surface.

9.3.2.2 Ignition Source and Explosion

A worker is removing brush in the vicinity of the west portal with a chainsaw and doesn=t notice the gasoline odor because (s)he has just fueled the chainsaw. The spark is created when the chain saw hits a rock. Ignition could also occur if the worker lit a cigarette or removed some nylon clothing and created a spark of static electricity. The fuel-air mixture instantly ignites and causes an explosion in the tunnel.

9.4 IMMEDIATE IMPACTS AND RESPONSE

9.4.1 IMMEDIATE IMPACTS

9.4.1.1 Injuries

The worker, the only person standing near one of the tunnel portals in this scenario, would be injured with severe burns and possibly even killed. The explosion sends a fireball and pieces of rock and concrete out of the east portal and across the frontage road and I-5. Vehicles within approximately 1000-feet of the east portal are likely to be damaged (Wagner 1999). Some drivers lose control and crash when their vehicles are swayed and their windshields damaged by overpressures associated with the shock wave. Other drivers, surprised and frightened, also lose control and crash. These accidents cause injuries and possible fatalities to the drivers and occupants.

9.4.1.2 Damage to Tunnel

The explosion also opens fractures in the concrete and bedrock surrounding the tunnel. This further weakens the tunnel lining causing the roof to collapse in several places. In addition, unburned fuel is forced into the fractures where it becomes a source for groundwater contamination.

9.4.1.3 Forest Fires

The explosion ignites vegetation within hundreds of feet of each portal and two forest fires begin.

9.4.1.4 Damage to Pipeline

The explosion could cause the pipeline to rupture, which would release another 15,200 gallons of gasoline into the tunnel. The 15,200 gallons was determined assuming 4-minutes of flow while pumps and valves close. Additional fuel would probably be released if the valves were closed manually.

In a variation on this scenario, the pipeline could be damaged in a way that the pressure drop is not large enough for the SCADA system to immediately detect. In this happens, the pumps and block valves probably would not be shut down until after the explosion and fire were reported. Depending on how long this takes, additional fuel would be released into the tunnel.

Gasoline spilled as a result of a rupture probably may not immediately burn because there would be reduced oxygen left in the tunnel after the explosion. Unburned gasoline would flow into fractures in the rock and toward the west portal. Depending on temperature, airflow and other variables, some of the gasoline would vaporize. The gasoline vapors could then sustain continuous fires near both portals.

9.4.1.5 Damage to Structures

Structures within the line of blast and within approximately 1000-feet could also sustain damage. The amount of damage depends on their distance from the tunnel and the overpressures associated with the shock wave.

9.4.1.6 Impacts to Surface Water and Fish Populations

Gasoline liquid could reach and mix with water in Rockdale Creek and flow into the South Fork Snoqualmie River, causing acute toxic impacts to fish and other aquatic organisms.

Depending on the fracture density and hydraulic conductivity of the rock surrounding the tunnel after the explosion, groundwater seepage through the rock could be significantly increased. This could cause emptying of the lakes located over the tunnel and seepage of fuel-contaminated water into the fractured rock under the tunnel.

9.4.1.7 Interruptions of Communications

The explosion, heat, and fuel could damage the fiber optic cables in the tunnel, disrupting AT&T and MCI Worldcom communications.

9.4.2 IMMEDIATE RESPONSE ACTIONS

9.4.2.1 Injuries and Fire

In this scenario, the explosion ruptures the pipeline, the pressure drop is detected by the SCADA system, the pumps shut down and block valves close. This sequence of events reportedly takes about four minutes. During these four minutes, fuel would flow out of the rupture. Since the release occurs near the high point of the pipeline, it is assumed that little drainage of gasoline toward the rupture location occurs after the pumps stop and valves close. The nearest block valves are located at Mileposts 54.80 and 67.07 (Application p. 2.9-7).

OPL personnel and a response trailer are mobilized and arrive at the site after 2.5 hours. The slow response time is likely due to the excessive traffic caused by closure of I-5. In addition, fire response equipment and EMT personnel and helicopters arrive and begin treating and taking the most seriously injured victims to hospitals. Cleanup contractors are contacted and arrive at the site within about 5 hours. Forest fire suppression crews arrive after about 6 hours. However, they are not allowed to begin their work until the following day when it is confirmed that there are no hazards from additional releases of gasoline.

9.4.2.2 Containment and Recovery

Containment booms are deployed in Rockdale Creek and the South Fork Snoqualmie River to recover floating product. However, due to turbulent mixing of fuel and water, very little is recovered.

9.5 LONG-TERM IMPACTS AND MITIGATION

9.5.1 LONG-TERM IMPACTS

9.5.1.1 Injuries and Deaths

Injuries and deaths will have long term impacts on families.

9.5.1.2 Damage to Tunnel

Heat from the fire and shock from the explosion will probably cause severe damage to the tunnel liner, which reportedly is in poor shape. The tunnel will be closed to the public until repairs are made. Unburned fuel residues would be present in the ballast and fractured rock of the tunnel. If petroleum vapors are present after repairs are finished, the Parks Commission may keep the tunnel closed.

9.5.1.3 Revegetation

Revegetation is required where cleanup activities have disturbed the soil and where fire has destroyed vegetation.

9.5.1.4 Soil and Fractured Rock Contamination

Fuel residues would remain in fractured rock and fill materials on the floor inside the tunnel, and soil outside the tunnel west entrance. Some of this fuel will leach into groundwater and become a secondary source to surface water bodies.

9.5.1.5 Surface Water and Fish Populations

Chronic impacts to fish populations may occur if contaminated soil, fractured rock and groundwater serve as secondary sources of petroleum contaminants. The potential impacts are difficult to evaluate.

9.5.1.6 Interruptions in Communications

Repair of damaged fiber optic cables may not be possible until the tunnel is safe enough to work in. This may take days or weeks. The resulting loss of the fiber optic cables may create interruptions in service.

9.5.1.7 Interruption in Pipeline Service

Repair of the damaged pipeline also may not be possible until the tunnel is safe enough to work in. This may take days or weeks. If a fuel shortage develops in eastern Washington, fuel will probably be brought in by truck. Depending on the number of trucks required, a fuel shortage could occur.

9.5.1.8 Groundwater Contamination

Groundwater contamination is likely. Proper evaluation requires information that is not contained in the Application.

9.5.1.9 Economic Impacts

Long term impacts from explosion and damages may cause a temporary loss of recreational and business activity in the neighboring resort community.

9.5.2 LONG-TERM MITIGATION

In the situation described, there are likely to be a number of long term activities. Geotechnical studies will be needed to evaluate the safety of the tunnel and to design repairs. Subsurface monitoring of contamination in fractured rock, soil, and groundwater will be required. This may be necessary for many years. Nearby water supply wells will also require monitoring.

Studies of stream ecology and impacts would be needed. These studies could be extensive if the fuel propogates through the rock fractures and continues to leach into surface water for a long time.

10.0 SWAUK CREEK SPILL SCENARIO

10.1 INTRODUCTION

The purpose of this scenario is to illustrate the reasonably likely impacts from a slow leak and pipeline rupture of small to moderate size from the proposed Cross Cascade Pipeline (CCP) in the upper and middle Yakima River basins. Over the life of the pipeline, a spill in the upper or middle Yakima Basin is highly likely given construction, maintenance and operation difficulties associated with the geologic and topographic setting and the relative remoteness. To demonstrate the impacts of a release in this area, a spill scenario is located along the Swauk Creek drainage. This drainage is one of over a dozen named Yakima tributary creeks crossed by the CCP west of the City of Ellensburg. Swauk Creek is typical of these tributaries in that it is a low to moderate gradient stream that supports the Upper Yakima anadromous fishery. The location of the Swuak Creek crossing is shown on the attached figures.

10.2 SETTING

Swauk Creek is located in Kittitas County in township 19 north, range 17 east. The CCP route crosses the creek in Section 17, about 1 mile upstream from the Yakima River confluence and about 3 miles after it crosses the Yakima River. The Swauk Creek crossing is number 151 in the Application and occurs at approximately pipeline milepost 99.5. Besides the main creek crossing, the pipeline crosses three unnamed tributaries of Swauk Creek between mileposts 150 and 153. All of these unnamed creeks enter Swauk Creek within a half mile of the main creek crossing. The unnamed creek crossings will be dry trenched. Swauk Creek will be crossed using a flume diversion method (Table 3.3-6).

Much of the CCP in the upper Yakima basin follows the Bonneville Power Administration (BPA) right-of-way. However, between about mileposts 99 and 100.5, the proposed pipeline diverts from the BPA right-of-way approximately one half mile to traverse the steep canyon sidewalls of Swauk Creek. At the location of the crossing, the creek runs almost due south. The west canyon sidewall drops 460 ft at an average 15 percent grade. The east canyon sidewall drops almost 760 ft at an average 25 percent grade. In places, these sidewalls steepen to near 100 percent slopes (Table 3.1-6).

The pipeline is 14 inches in diameter and is buried beneath 36 inches of dirt (p. 2.3-9). The closest block valves are at milepost 96.19 (Yakima River Crossing) and at milepost 108.73 (North Branch Canal and Currier Creek). Though not identified as such in the Application, Swauk Creek contains a number of high risk factors that make it susceptible to a leak. The area is located near the Yakima fold belt, which is one the most seismically active regions of the state for shallow crustal earthquakes (p. 3.1-15). The area is also located in a complex geologic environment with very steep slopes and documented nearby landslides. The stream channel is described as unstable with evidence of dramatic channel shifts and downcutting. These site conditions may be extreme relative to typical conditions, however they are not unusual for the mountainous regions of the Cascades.

10.2.1 SPILL DESCRIPTION

For the purpose of this spill scenario it is assumed that a slow leak is caused initially by a shallow crustal earthquake probably associated with the Yakima fold belt to the south. The size of the earthquake is magnitude 5.5. A magnitude 5.0 aftershock occurs about 72 hours later causing the pipeline to rupture. The earthquake occurs approximately 20 kilometers to the south along the north end of the Manastash Ridge. Until this event, the ridge was not recognized as an active fault. However, the area around Swauk Creek is recognized as capable of random shallow earthquakes at a credible maximum magnitude of 6.5 (Geomatrix 1988). The reoccurrence interval for the 6.5 event is estimated at 50,000 years; a 5.5 magnitude would have a significantly shorter return period. In fact, earthquakes of 5.2 and 5.5 magnitude were recorded in the central Cascades this century (Table 3.1-1). Random earthquakes are not uncommon in Washington. For example, the recent (March 1996) magnitude 5.3 Duvall earthquake along the western end of the CCP alignment did not occur on an identified fault.

The earthquake causes horizontal ground accelerations at the pipeline location of approximately 90 cm/sec^2 (Krinitzsky et al. 1988) (about 0.1 g). The aftershock causes ground accelerations of about 60 cm/sec^2 (about 0.06 g). These accelerations are less than the minimum acceleration design criteria of 0.3 g set by the Seattle Water Department for new construction (Harrington 1998). Even so the accelerations are strong enough to cause movement of soil and the pipeline at the creek crossing resulting in a leak and fracture.

Failure and slope movement of the heavily fractured basalt and overlying alluvium causes the actual pipeline break. However the break could also have occurred by a number of other mechanisms associated with an earthquake. Differential movement along the length of the pipe where it transitions from basalt to the unconsolidated alluvium of the valley bottom could damage and rupture the pipeline. Liquefaction of the alluvial channel sediments could also result in a pipeline break.

The original leak is small, about 25 gallons/hour, below the detection of the SCADA pressure monitoring system or inventory control detection methods. By the time the aftershock arrives (72 hours later) 1,800 gallons of diesel has leaked.

When the pipeline ruptures, the break is recorded and the pipeline is shut down within four minutes. The pipeline is flowing diesel at the minimum rate of 1,000 barrels/hour because of the initial earthquake (Table 2.9-4). About half of this flow rate leaks from the ruptured pipe during the first four minutes. Total leakage during this time is about 1,400 gallons. The rupture continues to leak through line drain down between topographic high points on either side of the rupture. The topographic high points extend from about mileposts 97.5 to 100.5 for a total of about 3 miles of line drain down. Based on an estimated line displacement of about 1,000 barrels per mile (Table 2.9-5), the potential drain down is 126,000 gallons. About half of this volume actually drains from the pipeline for a total drain down spillage of 63,000 gallons. Ninety percent of drain down occurs within the first two hours of the rupture.

Because the spill occurs at night during relatively heavy rain, OPL has problems actually locating the spill. Within 4 hours after the spill, product is located on the Yakima River. Response crews reach the initial spill discovery location within 8 hours. Booms are set downstream at approximately 10 hours after the break; approximately the same time the leak is discovered at the source.

10.2.2 GEOLOGY

Swauk Creek is located in a complex geologic terrain. The geologic units crossed by the proposed route are described in the Application (p. 3.1-6). However, more detailed descriptions are found in Tabor and others (1982) and Kinnison and Sceva (1963).

The surficial geologic units in the vicinity of the Swauk Creek crossing are basalt (geologic unit Tb on Atlas Page Number 43). This bedrock unit is part of the Columbia River Basalt (CRB) group that is underlain by the Roslyn formation consisting of sandstone and shale (Kinnison and Sceva 1963). Tabor and others (1982) indicate that the basalt is folded into a syncline (the Kittitas Valley Syncline), a U-shaped fold whose axis is located about one half mile south of the proposed creek crossing. The fold is gentle and the basalt flows generally are inclined less than 10-degrees to the horizontal in this vicinity. The basalt forms a topographic ridge that is attached and continuous to the south side of Lookout Mountain. Locally, the basalt is mantled by till, colluvium and alluvium.

The CRB in this area is associated with extensive landslide activity. The transmission line alignment contains landslide deposits within Swauk Creek a few hundred feet from the currently proposed alignment (Atlas p. # 43). Presumably, the CCP is routed south approximately one half mile to its current location to avoid these deposits (geologic unit Qls on Atlas Page 43). However, the current crossing appears to have the same underlying geology and only moderately less steep slopes. In general, the landslide deposits are common on the sides of Lookout Mountain. Tabor and others (1982) have mapped landslide deposits and Alandslide of large blocks@ on most sides of Lookout Mountain at a scale of 1:100,000. These deposits are within about 2.5 miles of the Swauk Creek crossing. The landslides are associated with basalt slopes and also are common, for example, in Taneum Canyon (approximately 4-miles south).

At the crossing, the canyon is incised up to 600 ft into the CRB with steep slopes on both sides. Silt and sand colluvium mantles the basalt (p. 3.7-10). Beneath the creek, the pipeline would be buried in alluvial deposits (Qao and Qa) along and under Swauk Creek. The Application (p. 3.1-6) describes these as clay-rich sands and gravels. However, Tabor and others (1982) describe Qoa as a boulder to pebble gravel glacial outwash. Kinneson and Sceva (1963) describe these deposits as Acoarse alluvium of unknown depth.@ The liquefaction potential at the crossing is not specifically characterized (Table 2.15-3).

10.2.3 GROUNDWATER

The CRB that occurs at the Swauk Creek crossing is part of a basaltic ridge the separates two adjacent groundwater basins. The Kittitas groundwater basin is located to the east of the creek. It consists of a deep basin of Tertiary deposits of the Ellensburg formation overlain by relatively thin quaternary alluvium. To the west of the crossing is the Roslyn groundwater basin (U.S. Department of Interior 1999) or lower Teanaway groundwater subbasin (Kinneson and Sceva 1963). Neither of the basins were identified in the Application.

Within the Yakima basin, folded CRB structures form topographic ridges. Groundwater tends to infiltrate readily down dip at these ridges along the basalt flow contacts resulting in groundwater highs. Groundwater flow in the basalt at this location is highly complex due to heavy fracturing associated with folding and faulting in the area. The CRB is considered an important aquifer source in the upper Yakima basin (Kinneson and Sceva 1963).

10.2.4 SURFACE WATER

Swuak Creek is a DNR type 2 stream. Based on the Application=s methodology, the stream has a hydrologic sensitivity rating of 9 (Table 3.3-5). Similarly, the fisheries sensitivity index is listed as moderate (Table 3.4-8). At the crossing, the creek has a gradient of slightly greater than 1 percent (55 ft/mile) based on topographic maps. A gradient of 2 percent (Table 3.3-6) may be more characteristic of the creek. As stated in the Application, the maximum channel depth is 2.5 ft, the average bankfull depth is 1.8 ft and the bankfull width is 49.2 ft. The creek low flow is about 5.3 cfs. The Yakima River directly downstream has a low flow of about 450 cfs.

The Soil Types and Erosion Hazard Map (Atlas Page Number 43) indicates that the soil located above Swauk Creek canyon has moderate and high erosion potentials. In the canyon, the soil is characterized as having low to moderate erosion potential. The erodibility index assigned to the creek at the crossing is a 3. This is the highest rating given in the Application=s stream crossing rating scheme. This high rating indicates a fine erodible substrate of fine sand/silt and clay (Table 3.3-5). In contrast to this rating, the text states that the channel is dominated by gravel substrates (3.7-10). Given these contradictions, the erodibility of the stream channel (probably the most important construction related impact parameter) should probably be characterized as unknown in the Application.

10.2.5 FISH AND WILDLIFE

In general, Swuak Creek is characterized as relatively unremarkable in the application. The channel is described as being Aunstable@ and heavily grazed by livestock (p. 3.4-63). The creek is characterized as having resident salmonoids, but not sensitive or anadromous salmonoids (Table 3.4-8). This is in contrast to the draft Environmental Impact Statement (DEIS) (Jones & Stokes 1998) which list spring chinook and summer steelhead [steelhead is proposed for listing under the Endangered Species Act (ESA)] occurring at the crossing. The DEIS also lists bull trout occurrence at the crossing; this species is threatened under the ESA and is a Washington State priority species. Not mentioned in the Application are species that are already extinct in the basin or fish reintroduction projects that may be in progress and may be impacted by the pipeline project. For example, the Bonneville Power Administration in conjunction with the Yakima Tribes is evaluating a reintroduction program for Mid-Columbia coho salmon (BPA 1999).

The Application does admit that Athough in degraded condition@ portions of the creek provide rearing habitat for spring chinook, steelhead, bull trout and other species. In contrast, The Nature Conservancy characterized this area as Aa well-developed riparian corridorY that supports large populations of resident fish@ (James 1995). Spawning bull trout and steelhead were captured in the creek, and Washington Fish and Wildlife has captured large numbers of spring chinook that rear in the lower reaches of the creek. The Nature Conservancy considered purchasing a 3,200 acre ranch located at the pipeline crossing (Cooke 1999). In addition to fish habitat, The Nature Conservancy considered the area to Ahave considerable significance from a plant community perspective@ and the Ariparian zone is generally in a state of recovery from past disturbance and has a good potential for restoration activities that could speed this recovery@ (Chappell 1995). Central Washington University (CWU) also considered purchase of the same ranch. Daniel Beck, director of the CWU Yakima Basin Center indicated that the creek was one of the best preserved drainages of the Upper Yakima (Beck 1995?).

The difference between the Application=s assessment and other independent assessments (including the DEIS) may be simply one of perspective. While some parties see the creek as being extremely healthy and important for the Upper Yakima anadromous fishery, the Application sees an over grazed creek without migratory fish. Given these contradictions, the actual fishery conditions of the creek should probably be considered uncharacterized. However for the purpose of this scenario, we will assume that the fishery is similar to that described by The Nature Conservancy.

10.2.6 WATER USE

Water in the Yakima River basin is heavily used for consumptive and non-consumptive uses. Ecology estimates groundwater use at 392,891 acre-ft (U.S. Dept of Interior et. al 1999) with over half being for irrigation. Surface water diversions in the Kittitas Valley are about 500,000 acre-ft, primarily for agricultural uses. The Cascade Canal diversion occurs from the Yakima River approximately 2.5 miles downstream of the Swauk River crossing. According to United State Geologic Survey (USGS) there is a pumping station in the Yakima at its confluence with Swuak Creek. A number of other agricultural water diversions occur within the ten miles downstream of the confluence.

Based on the Ecology files (Water Rights Application Tracking System) there are five water right claims (dating to 1900) within section 17 where the crossing is located. The claims are from a well, the creek and springs.

10.3 SPILL SCENARIO

A pipeline leak and rupture is postulated to occur along the east wall of the canyon. The leak and rupture are caused by an earthquake induced landslide. The landslide occurs as a toppling type or wedge type failure (Norrish and Wyllie 1996). The initial earthquake weakens the rock resulting in earth movement of the bedrock beneath and adjacent to the trench. A leak subsequently occurs at a weld. This weld fails during the aftershock. The leak and spill are postulated to occur during mid October when Swauk Creek is at it lowest flow of about 5.3 cfs. The Yakima is flowing at about twice its low flow or about 1000 cfs.

10.3.1 DESCRIPTION OF RELEASE

After the earthquake, approximately 1800 gallons of diesel leaks from the pipeline over three days. About 25 percent of the diesel is retained as residual saturation in soil backfill. The remaining 525 gallons infiltrates into the highly permeable basalt.

The rupture spills approximately 56,700 gallons in the first four hours. Product erodes the backfill and discharges to the surface about 30 feet in elevation above and 30 yards in distance from the creek. Because of the high leak rate and steep slope, about half the product reaches the creek. The other half soaks into the soil.

10.3.2 SPILL MOVEMENT

The total product that reaches the creek is approximately 28,700 gallons in the first four hours. This is equivalent to about 0.3 cfs or 5 percent of the total creek flow by volume. The spill reaches the confluence with the Yakima within about an hour and continues to move down the river at a rate of about 1 mile per hour (Application Appendix B-2). The flow passes the diversion for the Cascade Canal and a portion of the spill enters this irrigation structure. A number of other irrigation diversions are impacted including the West Side Canal upstream of Thorp.

10.3.3 INITIAL SPILL RESPONSE

Booms are place directly above the Town Canal diversion about 10 miles below the confluence. A total of about 10,000 gallons reaches the boom, and approximately a quarter of this product jumps the boom. A second set of booms contains most of the rest of the product another two miles downstream after some of the product reaches the Town Canal.

10.3.4 SPILL IMPACTS

Within Swuak Creek at the spill site and down to the confluence, fish mortality is 98 percent. Adult summer steelhead are just arriving at the creek and the run is decimated. All juvenile chinook and steelhead are also killed. Fish mortality in the mainstem river reaches 30 percent in the vicinity of the confluence and decreases to near zero at the final containment boom downstream. The fishery in Taneum Creek, entering on the west bank of the Yakima is also affected. Fisheries in this creek were not evaluated in the Application because the pipeline does not cross it. About 40 percent of the product that originally reaches the river either dissolve, evaporate, or are smeared along the shoreline. About 10 percent of the product is entrained as droplets within the water column and travels initially undetected downstream. Olympic attempts to the clean up the smeared product along the shoreline but only recovers about 10 percent of the estimated 5,740 gallons of residual oil along the banks. The rest is left to evaporate or naturally attenuate. Attenuation of diesel is slow as winter conditions arrive. Fish mortality, stress and avoidance continue throughout the next year. The cost to fishery recovery and reintroduction programs of Washington State, the Bonneville Power Administration, and the Yakima Tribes are significant.

Initial cleanup efforts concentrate on the mainstem river. Consequently, booms and cleanup crews are not available for the diversion canals. With the exception of the Town Canal, these other irrigation diversion canals are significantly impacted. Extensive clean up, booming and water testing is required prior to full resumption of irrigation operations. The cost to irrigation districts is substantial.

At Swuak Creek, approximately 1,800 yards of contaminated soil is removed. Removal further destabilizes the hillside causing extensive slope stabilization actions. Slope stabilization and pipeline repair cause the pipeline to be out of commission for an extended period. The riparian zone within the creek in the vicinity of the spill is decimated. Additionally, the riparian zone is significantly effected all the way to the mainstem confluence due to the product and cleanup efforts. Remediation efforts are attempted to address contamination and free product within the bedrock. A dozen wells are drilled however after the first year only 20 gallons of product are recovered. The decision is made to abandon remediation efforts due to the ineffectiveness of this technique in the fractured bedrock environment. Six months later, a sheen is noticed on the creek 300 yards downstream of the spill site. The cause is contaminated groundwater seepage from the fractured bedrock into the creek.

The shallow well and creek diversion at the private residence, located just downstream from the crossing, are abandoned. Olympic agrees to drill a new deeper well to supply potable, stock and irrigation water.

After 10 years, the steelhead and bull trout fishery have not returned to the creek. The stream crossing location that Olympic had considered directionally drilling because of the presence of Bull Trout, no longer has Bull Trout or other anadromous fish (p. 3.7-20).

11.0 COLUMBIA RIVER SPILL SCENARIO

11.1 INTRODUCTION

The purpose of this section is to describe scenarios designed to illustrate the potential effects on the Columbia River of a large, rapid release and a small, slow leaks of fuel from the Cross Cascade Pipeline at the horizontal directional drill (HDD) crossing beneath the Columbia River, found approximately 2000 feet south of Wanapum Dam. The trigger for a rapid release is rupturing of the pipeline failure by a seismic event tied to any one of several Quaternary faults mapped within 5 miles of the crossing. The trigger for a small, slow leak could be any one of several mechanisms, including: 1) corrosion of the pipeline where gouging from a boulder damaged it during its original placement, 2) a failed weld, 3) defective pipe, or 4) weakening due to stress induced by channel scour (also a potential trigger for a rupture). The postulated leak occurs in late autumn to early spring, during lowest annual average stream flows, low temperatures, and during and following fall chinook salmon spawning, prior to downstream migration of smolts the following spring. The spill could impact: 1) fisheries' resources, 2) surface water, 3) recreation, 4) Wanapum Dam operation, and 5) pipeline service.

The scenarios explored herein are based on the premise that Columbia River HDD crossing conditions are essentially as portrayed in the application. Thus, it is assumed that the pipeline will be in a boring drilled entirely through Quaternary glaciofluvial gravel. However, the reader is referred to the chapter of this report on the Columbia River Crossing Chapter which demonstrates that existing physical conditions are likely to be much different than those described in the Application.

11.2 SETTING

11.2.1 DESCRIPTION OF PIPELINE AT THE SPILL LOCATION

The pipeline as currently described in the Application will pass beneath the Columbia River at stream crossing 223 approximately 2000 feet downstream of Wanapum Dam as noted on the attached figure. The pipeline approaches the Columbia River crossing from the north, on the upland surface west of Wanapum Lake (the Columbia River) at elevations of approximately 1000 feet above mean sea level (msl). At approximately milepost (mp) 147.5 the pipeline descends the upland surface to Johnson Creek, Getty's cove (elevation 590 feet msl), and the western bank of the Columbia River (Wanapum Lake).

From Getty's Cove, the pipeline parallels the county road right-of-way, along the base of the basalt bluff, south to, and beyond the west end of Wanapum Dam. At approximately mp 149.5 (elevation 520 to 530 feet above msl) the pipeline turns east, dips downwards, and from there passes beneath the Columbia River in a boring emplaced using horizontal directional drilling techniques. As described in the Columbia River Crossing Chapter, the actual geologic conditions expected to be found beneath the Columbia River described in geotechnical information prepared for the Wanapum Dam Project (Mackin 1955; Galster 1989) differs significantly from what is described in the Application. However, based on the conditions as described in the Application, the pipeline emerges from beneath the Columbia River at approximately mp 150 and then proceeds to the east beneath Highway 243 (elevation 555 above msl), up onto the 800 to 1000-foot msl upland surface found east of the river, eventually reaching the Beverly-Burke pumping station at mp 154.

The segment of the pipeline at the Columbia River crossing is 12 inches in diameter and has a volume of 2,900 bbl/mile of line. Information in the draft EIS gives an average flow rate for the pipeline of 5,417 bbl/hour. The block valves closest to the river crossing are at mp 148.39 at Getty's Cove west of the crossing and at mp 150.35 east of the crossing. The next closest block valve west of Getty's Cove and the crossing is found at mp 129.82, on the west side of Ryegrass Hill and approximately 20 miles away from the crossing. The next closest block value east of the crossing and the block valve at mp 150.35 is at the Beverly-Burke pumping station.

11.2.2 HYDROGEOLOGY

North of Getty's Cove and Johnson Creek the pipeline is directly underlain by basalt bedrock. At Getty's Cove and the crossing of Johnson Creek, Quaternary alluvium (Qa) of unknown thickness underlies the pipeline. After crossing Johnson Creek the pipeline returns to a basalt substrate, staying on that until approximately mp 149.5 where the pipeline turns east. From this point to the river, the pipeline is within a gravel bar consisting largely of Quaternary cataclysmic flood gravel and sand (Qfg). Based on the conditions described in the Application, the pipeline will be found in Qfg all the way beneath the Columbia River. Qfg near Wanapum Dam typically consists of uncemented, interstratified basaltic sand, pebble to cobble gravel, and boulder gravel (Mackin 1955). Application Table (2.15-3) gives a liquefaction rating of five (highest) to Qa, three to Qfg, and one (lowest) to basalt.

Several mapped faults described as Quaternary in age are present transecting and/or within 5 miles of the pipeline. Faults intersected by the pipeline are summarized on Table 1 of this report. Faults the pipeline comes near to, but are not intersected by it are summarized on Table 2. These faults are either ignored or deemed as not important in the Application.

The Application does not present a description of groundwater conditions at and beneath the crossing site. However, previously published reports (DOE 1988; Connelly and others 1991 1992; Swanson 1992) describe the hydrologic properties of the unique cataclysmic flood deposits that likely form the shores and bars on either side of the river and overlie basalt at the proposed crossing site to the extent necessary to estimate general groundwater conditions in the immediate areas of the crossing. For example, publicly available hydrogeologic information from cataclysmic flood deposits at the Hanford Site show that these uncemented strata typically have saturated hydraulic conductivities on the order of hundreds to thousands of feet/day. Because of the site location within a high energy, channeled scabland, cataclysmic flood tract, a high saturated hydraulic conductivity, potentially ranging from 1000 to 10000 ft/day is used for this scenario. The condition under which these deposits formed also argues for very low organic carbon content, <0.1%. The open framework texture of cataclysmic flood deposits (e.g., lack of fine matrix and cement) and abundance of large gravel clasts also suggests porosity ranges from 20 to 40 percent coupled with high bulk density between 1.9 and 2.0 g/cc (Piepho and others 1996). These conditions also suggest a high degree of hydraulic connectivity between the aquifer and the river. Given this, and an absence of site specific groundwaterdata, the water table at the leak site is assumed to have an elevation similar to the immediately adjacent Columbia River, ranging between 500 and 480 ft above msl. No groundwatergradient data is available for the site. For this scenario the groundwater gradient is estimated to be 0.001ft/ft with a slope to the east-northeast.

11.2.3 SURFACE WATER

The Columbia River at the crossing is a DNR type 1 stream (Application Table 3.3-6) and has a Department of Ecology class rating of A. The channel gradient in the area of the leak is estimated to be approximately 0.0002 ft/ft. Using estimates presented in Dames and Moore (1997) an average river discharge is assumed to be 90,000 cfs with a velocity of 3,360 ft/hr at the time of the leaks.

Besides the fish species present in this reach of the Columbia River described in the DEIS and Application, the reach of the river just downstream of Wanapum Dam contains spawning habitat and redds for fall chinook salmon (Rogers et. al. 1989; Dauble and Watson 1990; D. Dauble, personal communication 1999). The redds immediately overlie the position of the pipeline as it passes under the western bank of the Columbia River. Additional redds are described in Rogers and others (1989) approximately 1 mile downstream of the crossing.

11.2.4 LAND USE

Land on both the west and east sides of the river at the crossing is essentially undeveloped. On the west bank the land surface has been disturbed by Wanapum Dam construction and operations and recreational activity. The land bordering the eastern bank of the Columbia River is largely undisturbed except for undeveloped roads, trails, and right-of-ways. Most of the land on the west side of the Columbia River is owned by Grant County Public Utility District. Land on the east side of the Columbia River is owned by the Bureau of Reclamation.

11.3 SPILL EVENTS

11.3.1 INTRODUCTION

Both the rapid and slow leak scenarios occur in late autumn and early winter, during and following fall chinook spawning. At this time of year average stream flows and air and water temperature will be relatively low. Low stream flow reduces dissolution and dispersion rates for fuel leaked into the river while low temperatures will inhibit volatilization and biodegradation of fuel after it leaks from the pipeline. The various physical parameters for the leak scenarios are described in the previous section and summarized on the Table 3. Leaked fuel is assumed to be super unleaded with a benzene solubility of 67 mg/l.

11.3.2 RUPTURE

The postulated rupture is triggered by a seismic event in excess of ML 7.0 occurring on one of the Quaternary faults crossed by or close to the pipeline (Tables 1 and 2). Ground shaking occurs and the pipeline is damaged at two locations where the pipeline crosses geologic contacts between very different substrates. The locations are: 1) Getty's Cove and the crossing of Johnson Creek (mp 148.39) and 2) the turn in the pipeline at approximately mp 149.5 where it makes its approach to the crossing (Figure 1). Breakage occurs at these two locations because differential ground shaking in the two subsubstrates, solid bedrock and Qa/Qfg, causes enough stress to break the pipeline. In addition to pipeline rupture, the block valve at Getty's Cove is damaged and fails to close.

The leak at the Getty's Cove block valve will discharge directly into the Columbia River located a few tens of feet away. Because of the potential for additional breaks in the pipeline due to the postulated seismic event, it is assumed that the entire pipeline volume between the break and the next block value at mp 129.82 will not leak at Getty's Cove. A likely potential location for another break in the line during the seismic event is the large landslide approximately 2 miles north of Getty's Cove. Given this assumption, 243600 gallons is available to leak into the river at Getty's Cove from approximately 2 miles of pipeline between Getty's Cove and the landslide. If the break is exposed on the ground surface, almost the entire contents of the pipeline would empty directly into the Columbia River within one to two hours of the break. If the leak is underground, fuel leakage rates will be controlled by how rapidly pore fluids (water and air) can be displaced by fuel coming out of the ruptured pipeline. Factors controlling this will include pore fluid pressure and pipe fluid pressure. For this scenario it is assumed that approximately 150000 gallons leaks directly into the Columbia River. The remainder of the available fuel stays in the soil, on the ground, or in the pipeline.

Given the stream velocities listed in Table 3 and the distance between the leak and dam, the leak will begin going over Wanapum Dam or through the turbines within an hour of getting into the Columbia River. The dissolved and free phase petroleum will become well mixed into the water column. The plume will reach the redds below Wanapum Dam within two hours of the rupture. Assuming the gasoline plume is instantaneously and completely mixed into the water column comprising the western half of the river, gasoline concentrations of 0.2 to 0.4 mg/l are possible at the redds found below Wanapum Dam. However, it is more likely that mixing with the river is not instantaneous. In that case, downstream dispersion occurs and gasoline concentrations in the river on the order of 10 to 20 mg/l are likely at the redds.

The other postulated break, at mp 149.5, is approximately 1.1 miles from the break at Getty's Cove. Given this distance and the volume of fuel in the line at full capacity, an estimated 133980 gallons is available for a leak onto the gravel bar and into the gravel bordering the river. The rupture is buried approximately 5 ft beneath the bar surface approximately 1300 ft from the Columbia River. Leaked fuel will be forced to the surface as well as migrating laterally through the gravel bar and down to the water table. Because of the lack of any site specific data and the range of potential physical properties in gravel deposits, calculating the groundwater travel time of leaked gasoline and/or diesel fuel from the leak point to the river is speculative. However, using the range of possible physical properties on Table 3, travel times of one to several months from the rupture point in the pipeline to the river can be calculated. Travel times such as these assume the only source of free phase product is immediately below the break and there is no subsurface source plume of free product generated by the leak.

The actual travel time will depend on the volume of leak, organic carbon content and retardation factors, size of an initial spill footprint on the ground surface and under ground and distribution of free product source, groundwatergradient and velocity, depth to groundwater, and depth of mixing in groundwater. In addition, a free phase plume is likely to form below and radiating outward from the leak. The size of this feature will depend on the lateral spreading of fuel in the vadose zone as it moves downwards. Once fuel begins to accumulate as free phase product on top of the water table it will also move toward the river. At this time the site specific data for these parameters is not available. Given the range of possible variables for the crossing area, the range of possible benzene concentrations in groundwaterat the aquifer-river interface range from 20 mg/l to 40 mg/l.

An important factor that should be incorporated into a seismic scenario for pipeline rupture is response time for mitigation. However, given the unknown extent of seismic damage to the area's infrastructure (roads, bridges, communications) this is difficult to determine. Depending on infrastructure damage, spill response could be a few hours, many hours, or several days. The longer the response times, the farther the petroleum will spread across the surface before fuel soaks into the ground and the shorter the transport time to the river.

Another potential cause of pipeline rupture should be considered. Assuming the conditions described in the Application, the pipeline will be less than 10 feet below the base of the river channel. This places it within the depth predicted by Dames and Moore (1998) for channel bottom scour. Rupture could occur because of high stream flows leading to channel bottom scour, undermining of the pipeline, and structural failure of the pipeline. Approximately 180,000 gallons of fuel would be leaked into the river. Such an event would be most likely in the spring and/or late winter when river discharges are at their highest.

11.3.3 SLOW LEAK

The proposed method of pipeline construction beneath the Columbia River centers on multipass drilling of a boring through which the pipeline will eventually be pulled (Dames and Moore 1998). For this scenario, it is assumed that one or more boulders present in the gravel through which the finished pipeline is pulled will become dislodged during the pipeline placement. These dislodged boulders will scrape against the pipe during pullback operations. These scrapes become points of weakness that can preferentially corrode. Corrosion will eventually form a hole, and fuel will be released into the substrate surrounding the buried pipeline.

For this scenario the leak is assumed to be located beneath and just east of the western shore of the river. Based on OPL descriptions of pipeline position, a leak at this location will be within 30 ft of the river bottom. Leaked fuel, having a lower specific gravity than water, will migrate upwards through gravel underlying the river channel to the base of the river channel. Given the estimated groundwater travel time shown on Table 3, fuel leaked at this location would reach the bottom of the western side of the river channel, and the salmon redds within several days. Fuel reaching the river channel bottom will consist of a mix of dissolved and free phase products that are introduced directly into salmon redds.

Even a relatively small leak representing 0.1% of total pipeline volume will result in the release of a significant volume of fuel to the gravel underlying the river channel bottom. This size of a leak results a leak rate of 227 gallons per hour at the maximum operational flow rate for this segment of the pipeline. Over a one year period of a potential slow leak approximately two million gallons of fuel could be released. Given this volume of fuel (and all of the uncertainties described earlier), dissolved phase benzene concentrations in the substrate immediately underlying the river bottom will be close to saturation concentrations. In addition, the proximity of the leak to the river bottom (<100 ft) suggests that free product adhering to sediment particles and as free floating droplets could be present.

11.4 CONSEQUENCE OF LEAK

Both the rapid, rupture-based leaks and the slow leak scenario will generate short-term and long-term effects. Examples of these effects for the rupture leaks include:

Fish ladder at Wanapum Dam is in the direct path of Getty's Cove rupture and is rendered unusable during peak salmonid run

Dissolved and free phase plume going over Wanapum Dam spillway drives spawning fall run chinook salmon away from redds below the dam

Rupture at mp 149.5 contaminates southern half of gravel bar on west bank of the river. Dissolved and free phase product leaking from the bar into the river renders spawning habitat adjacent to the west bank unusable until the channel bottom gravels and the source of fuel leaking into these gravels are cleaned up

Habitat restoration becomes necessary to return spawning habitats to usable conditions

Fuel supplies to Pasco are disrupted for an extended time period.

Examples of the effects of a small leak includes:

Free phase and dissolved phase fuel migrates into salmon redds adjacent to the leak site within days of initial release. Eggs and salmon suffer toxic effects

Undetected fuel contamination in the river substrate along the west bank drives newly arrived spawning salmon away. Undetected fuel in the river disrupts salmonids migrating past Wanapum Dam

Once detected, clean up has limited success because of inaccessibility of leak beneath river channel. Habitat remains contaminated until natural degradation reduces contaminant concentrations

If repair is attempted, habitat is further disturbed by drilling and grouting or potential trenching, depending on repair scenarios

Fuel supplies to Pasco are disrupted indefinitely.

11.5 CONCLUSIONS AND RECOMMENDATIONS

The results of this spill scenario have resulted in the identification of several recommendations for further work. These recommendations include:

Fall chinook salmon spawning habitat has been identified at the proposed HDD crossing site. The Application does not acknowledge this. Therefore, no mitigation and habitat protection plans are described in the Application. This oversight needs to be addressed by conducting an up-to-date survey of spawning habitat and proposing appropriate habitat protection.

The geologic literature for the region points to the probability that several mapped faults near the Columbia River crossing are Quaternary in age, and potentially Late Quaternary in age. These structures are potential seismogenic sources and need to be evaluated in the Application. The results of this evaluation should be incorporated into design of the pipeline.

Consideration should be given to changing the location of the Getty's Cove block valve. The present location is on the most highly liquefiable of all the materials the pipeline crosses (according to the liquefaction susceptibility ratings in the Application). Also, it is within in a few tens of feet of a significant change in geologic materials underlying the pipeline (i.e., a change from solid rock to saturated alluvium).

The gravel underlying the river and comprising both banks has high hydraulic conductivity, porosity, and permeability. Ground water flow velocities through these strata is relatively rapid. A leak into the gravel on either side of the river will move to the river in days to weeks (depending on the distance away from the river the leak occurs). A leak from the pipeline below the river channel will move upwards to the base of the channel within a matter of days. These rapid transport times argue strongly for double wall pipe.

Given the high degree of aquifer/river connectivity likely at the HDD crossing a leak into the gravel aquifer bordering the river has a high potential to contaminate the river and salmon spawning habitat. Also, geotechnical siting data for Wanapum Dam shows a significant portion of the proposed HDD crossing will be in basalt bedrock, not the gravel described in the Application. Given this, a bedrock boring should be evaluated.

The issues addressed in this scenario suggest that alternative crossing options should be reevaluated.

Table 1. Quaternary Faults Intersected by Pipeline

Fault	Location	Basis for Age	References
Boylston Mtn Anticline	West side of Ryegrass Hill	Basalt faulted over Alluvium	Bentley and Powell (1987), Tolan and Reidel (1989), Schuster (1994)
Wanapum-Sentinal Gap	Columbia River	Linked to Quaternary Saddle Mountain fault	Tolan and Reidel (1989), Reidel and Fecth (1994), Geomatrix (1990, 1996)

Table 2. Quaternary Faults near the Pipeline

Fault	Location	Basis for Age	References
Hog Ranch anticline	Ryegrass summit area	associated with sag ponds	Bentley and Powell (1987), Tolan and Reidel (1989)
Frenchman Hills	North side of Frenchman Hills	topographic expression	Geomatrix (1990, 1996)
Saddle Mountains	North side of Saddle Mountains	topographic expression	Reidel (1984), Reidel (1988), Geomatrix (1990), Reidel and Fecht (1994), West and others (1996)

Table 3. Physical Parameters for the rupture leak scenario

Pipeline Parameter	**Hydrogeology**	**Columbia River**
vol B 2,900 bbl/mile; 121800	Ksat B 1000 to 10000 ft/day Gradient B 0.001 ft/ft	discharge B 90,000 cfs velocity B 3,360 ft/hr
max. flow rate B 5,417 bbl/hr; diameter B 12 in 0.1% of flow B 227 gal/hr	Water table elev. at mp	
	Depth to water table B approx. 30 ft	
	Porosity B 30%	
	Organic carbon B 0.5%	
	Groundwater velocity B 3.3 to	
	Sediment bulk density B 1.9-	

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